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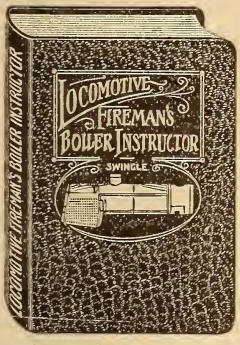

THE first pages of this book are devoted to the fireman's duties, as pertains to getting his engine ready for the trip, how he should perform his duties whilst out on the road, and what his portion of the work of taking care of the locomotive is at the end of the run. This book not only tells the fireman WHAT he should do, but tells him HOW the work may be best accomplished. Every detail of the locomotive fireman's work receives attention. The action of the draft, the best method of regulating the same, also a complete description of the construction and operation of the various devices for creating a draft in a locomotive, all receive attention. Within the past ten years a large number of labor-saving appliances have been attached to the locomotive. Among these we may mention the mechanical stoker, of which there are several kinds, each having its own particular merit. Lubricators of all standard makes. The various devices for burning fuel oil on oil burning locomotives, mechanical bell ringers, etc. All are fully described and illustrated. The subject of combustion of fuels is thoroughly handled in a way which easily brings it within the comprehension of the dullest mind. All of the different types of modern locomotive boilers, including the water tube boilers used on some of the roads in Europe, are each fully described and their construction clearly illustrated. The proper method of bracing and staying the locomotive boiler is treated upon at length. The fireman should be thoroughly familiar with the construction of the throttle and the dry pipe, and the route of the steam in its passage from the dome of the boiler to the steam chests. This knowledge he will get by a study of this book. All of the various equipments of a locomotive, such as steam gauges, water glass and gauge cocks, water tank strainers, pop valves, superheaters, check valves, injectors, inspirators, etc., are described in detail and illustrated and the best and most reliable method of handling them is given. The book closes with a valuable collection of advice and information for firemen and engineers also, which has been gleaned from the highest authorities in the mechanical department of railroading.

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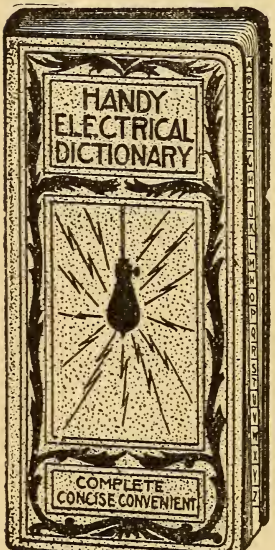

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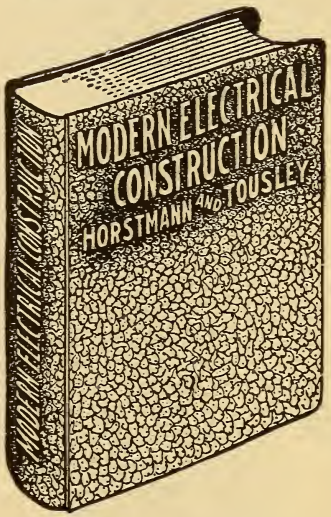

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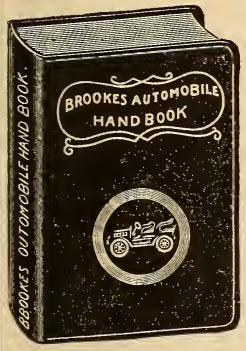

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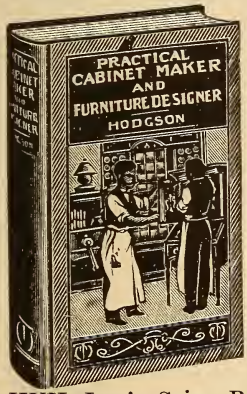

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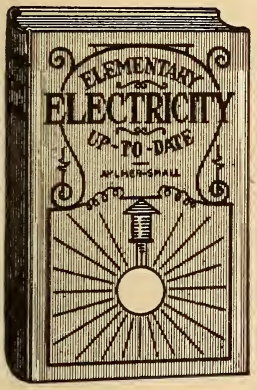

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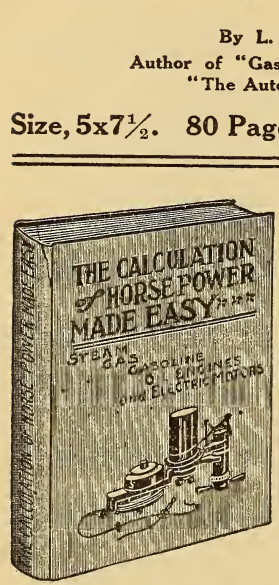

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latter, which would be the case with short trains, the higher auxiliary pressure moves the piston at once to Full-Service Position, Fig. 353, thus automatically cutting out the quick-service feature where it is not needed. When in Full-Service Position, Fig. 353, the service port *z* is fully open, and the quick-service port *o* is closed. This stops the flow of air from the brake pipe to the cylinder and the quick-service action ceases. As shown in the cut, the graduating spring is compressed slightly when the piston is in full service position. In any case where the brake pipe reduction is so rapid, that the quick service feature is of no advantage, the difference of pressure on the two sides of the triple valve piston becomes at the same time sufficient to compress the graduating spring, and automatically close the quick service port as explained above. But if the brake pipe reduction is less rapid, or slow, as in the case of long trains, or moderate service reductions, a partial opening only of the service port is sufficient to preserve a balance between the pressure on the two sides of the triple valve piston. The service port connecting the auxiliary reservoir to the brake cylinder, is much larger than the quick-service port connecting the brake pipe to the brake cylinder. This serves to effectually prevent an emergency application, when only a service application is desired. It also guards against the brake-pipe reduction being continued, due to the quick-service port remaining open, after the reduction has been stopped at the brake valve.

During the time the slide valve 3 remains in Quick or Full-Service Positions, as shown in Figs. 352 and 353, the cavity *q* connects the brake-cylinder port *r* with port *b*, leading to the safety valve. This safety valve, known as the E-7 (see Figures 348 and 349), is ordina-

rily set for 62 lbs. In an emergency application, however, the safety valve is entirely cut off from the cylinder, as explained under the heading "Emergency."

LAP.

After a sufficient brake-pipe reduction has been made, the brake-valve handle is lapped, and further escape of air from the brake pipe is prevented. When the flow

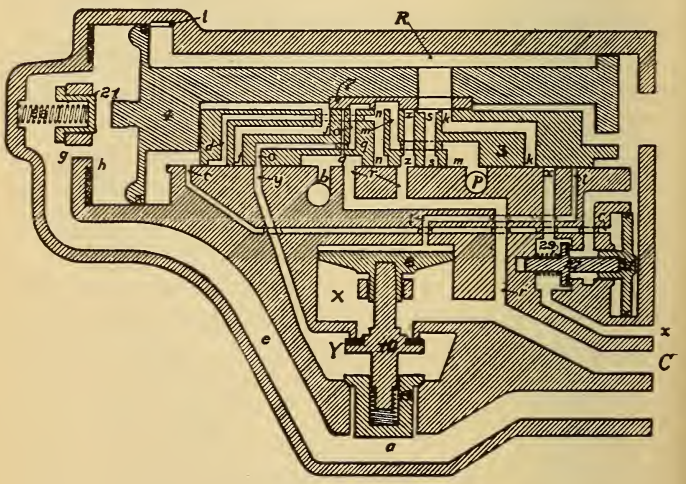


FIG. 354. SERVICE-LAP POSITION

of air from the auxiliary reservoir to the brake cylinder has reduced the pressure on the reservoir side of the triple-valve piston slightly below that remaining on the brake-pipe side, the pressure in the brake pipe, assisted by the graduating spring, will move the piston, and graduating valve to service-lap position, shown in Fig. 354. In this position all of the ports are blanked by the grad-

uating valve, and the flow of air to the brake cylinder is stopped. Further movement is prevented by the shoulder of the piston stem striking the end of the slide valve 3, as shown in the cut. The slight difference of pressure which was sufficient to move the piston and small graduating valve is unable to overcome the added resistance of the slide valve, and the parts remain in the position shown.

It should be noted that the slide valve 3 remains in Service Position, a movement of the piston and graduating valve being all that is required to lap the valve. Consequently, when in this position, only a slight reduction in brake-pipe pressure is required to again bring the piston and graduating valve into Service Position. It is evident that the exact position of the main slide valve in Lap Position depends upon whether its previous position was that of quick service (Fig. 352), or full service (Fig. 353). If the former, the lap position assumed would be that of quick-service lap (Fig. 354). If, however, the valve had moved to full service, the position would be that of full-service lap. The main piston being in service-lap position (Fig. 354), the pressure on both sides of it must be equal. If the brake-pipe pressure is increased in order to release the brakes, the higher pressure on that side of the piston causes it to move the graduating and slide valves to the extreme right to release, and recharging position, previously described (see Fig. 351). The air, which was prevented from leaving the supplementary reservoir by the former movement of the slide valve to service position, and which consequently remained at its initial pressure, while the auxiliary reservoir pressure was being reduced, now flows into the auxiliary reservoir and helps to recharge it.

During this operation, as well as while graduating

the release of the brakes, described under the next heading, the pressures on the brake pipe and auxiliary reservoir sides of the triple-valve piston are always in balance. This is important, since it insures an immediate response of the brakes to any reduction, or increase in brake-pipe pressure, irrespective of what operation may have occurred just preceding.

If the brake-valve handle is moved to Running Position and left there, the brake-pipe pressure is fully restored and the piston remains in Release Position; the brakes being thereby fully released and the auxiliary and supplementary reservoirs fully recharged.

GRADUATED RELEASE.

Suppose, however, that after the brakes have been applied, only sufficient air is permitted to flow into the brake pipe to move piston 4, with the slide, and graduating valves, to release position (Fig. 351), and the brake-valve handle is returned to lap. Then the flow of air from the supplementary reservoir, through ports *x* and *k*, to the auxiliary reservoir, continuing after the rise in brake-pipe pressure has ceased, the pressure on the auxiliary reservoir side of the triple-valve piston will be raised slightly higher than that on the brake-pipe side, and cause the piston, and its attached regulating valve, to move to the left, to graduated release position shown in Fig. 355. In this position the brake is only partially released, and a portion of the air pressure originally in the brake cylinder still remains there. In this way, the brake cylinder pressure may be released in a series of steps, or graduations, and the operation is known as grad-

uated release, and may be repeated as desired, until the brake-pipe pressure has been fully restored, and the exhaust of air from the brake cylinder completed. The amount of reduction in the brake cylinder pressure for any given graduation depends upon the amount of air pressure which has been restored in the brake pipe. The recharge of the brakes is similarly proportioned.

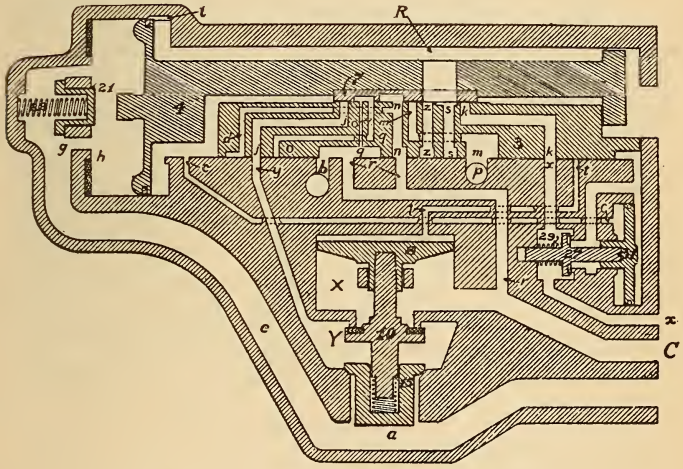


FIG. 355. GRADUATED-RELEASE-LAP POSITION

EMERGENCY.

When the brake-pipe pressure is reduced suddenly, or its reduction continues to be more rapid than that in auxiliary-reservoir pressure, the piston is forced to the extreme left and compresses the graduating spring. The parts are then in Emergency Position, as shown in Fig.

356. In this position air from the auxiliary reservoir enters the brake cylinder passage *r* through the port *s* in the main slide valve, instead of port *z* as in service application. Port *t* in the seat is also uncovered by the end of the main slide valve, thus admitting air from the auxiliary reservoir, through port *t* to the top of the emergency piston.

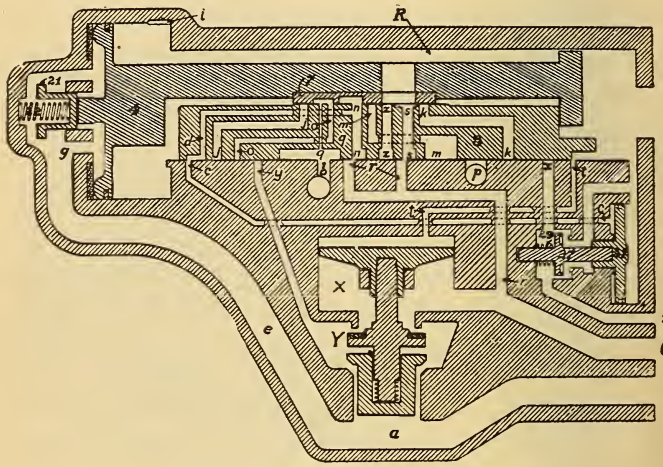


FIG. 356. EMERGENCY POSITION

The air pressure thus admitted to the top of this piston, pushes it down and forces the rubber seated emergency valve from its seat. This allows the brake pipe air in passage *a* to lift the emergency check valve, and flow through chambers *y* and *x* to the brake cylinder *C*, in the ordinary way. At the same time port *d*, in the main slide valve, registers with port *c* in the seat. This allows air from behind the by-pass piston to flow through ports *c*, *d* and *n* to *r*, and the brake cylinder. As there is no pressure

in the brake cylinder at this instant, the by-pass piston, with its attached by-pass valve is forced to the left by the auxiliary reservoir pressure acting against its opposite face. The air contained in the supplementary reservoir then flows past this valve into the passage way leading to the auxiliary reservoir. It thereby adds to the latter, the volume of the supplementary reservoir.

This gives in effect an auxiliary reservoir pressure volume approximately three times the size of the one that supplies air to the brake cylinder in a service application. Air from the supplementary reservoir continues to flow to the auxiliary reservoir until the pressures in the latter, and in the brake cylinder have risen nearly to that remaining in the supplementary reservoir. Communication between the two reservoirs is then closed by the by-pass valve returning to its seat.

This action of the triple valve in the emergency applications permits the pressure in the brake cylinder to rise to within a few pounds of maximum brake-pipe pressure, a much higher pressure being secured in emergency applications than is possible with the standard quick-action triple valve.

Further more it will be noted by reference to Fig. 356 that cavity *q* has traveled past the brake cylinder port *r*, so that the latter is no longer connected to the safety valve *b*. Hence, there is no escape of air from the brake cylinder after an emergency application of the brakes. Not only, therefore, is the emergency pressure considerably higher than that formerly secured by the use of the old standard High-Speed Brake, but it is held without diminution until the brakes are released.

INSTALLATION AND MAINTENANCE.

The triple valve is usually bolted to the pressure head of the brake cylinder, to which all the pipe connections are permanently made. In removing the valve, no pipes need to be disconnected, the loosening of the three bolts which hold it in place being all that is required. Hence, the name "Pipeless," as applied to this valve. Care should be taken in locating the valve to have it free from obstructions which would render inspection or removal difficult. It should be placed as far as possible above the general level of the piping so that no pockets are formed in the latter. If this point does not receive proper attention, trouble may be experienced in cold weather from the freezing of water in the pipes or valve itself. Under ordinary service conditions, the triple valve should be thoroughly cleaned and lubricated once in three months. The proper interval is best determined for each particular case by a careful inspection and trial. Where conditions are severe and the triple valve exposed to extremes of weather, dirt and so on, more frequent inspections will no doubt be found necessary. Where the valve is protected, and not subjected to hard usage the interval may be lengthened. The use of heavy grease or other lubricants which will "gum" and cause the valve to work stiff, or clog the ports, should be avoided. Too light a lubricant or one that does not possess sufficient "body," is not satisfactory, as it will not thoroughly lubricate the parts or last as long as necessary. Special lubricants made for this purpose will give the best results.

Before installing the triple valve all of the piping should be thoroughly hammered and blown out, in order

to loosen and remove all scale and foreign matter. This is especially important in new installations. After the piping is completed all of the joints should be thoroughly tested with soap suds, under pressure, and made air tight. Particular attention should be given to the safety valve and its strainers, in order that no dirt or scale can reach the safety valve seat and prevent it from properly closing. The by-pass piston should also receive attention to insure that it is working freely in its bushing.

Never remove the movable parts of the triple valve while it is on the car. If the valve is not working properly, or needs cleaning and oiling, take it down and replace it by a valve in good condition. All cleaning and oiling should be done at a bench, by a competent man; where the liability of damage to the internal parts of the valve is least. Any attempt to take the triple valve apart while still on the car is almost sure to result in a large percentage of valves being injured by careless handling, or dirt getting inside the pipes, or valve. If repairs are necessary the valves should be sent to the shops, where the facilities for doing the work are best.

The complete LN equipment includes a type L valve triple valve, with safety valve, a supplementary reservoir and a cut-out cock. At times, however, cars equipped with this schedule must be operated in trains with cars having the old standard equipment (P triple valves), as for instance during the transmission period when a change is being made from the old standard to the LN schedule.

During this time the cut-out cock between the triple valve and supplementary reservoir should be closed. The new valves will then work in perfect harmony with the old. In fact, if old and new equipments are to be

in service together for any considerable length of time, the cut-out cock and supplementary reservoir may be omitted entirely, as well as the safety valve, furnished with the triple valve. If the equipment is used with 70 lbs. brake-pipe pressure, no other change is necessary, and only the addition of the ordinary High-Speed Reducing Valve is required for High-Speed Service (110 lbs. brake-pipe pressure). In such cases where the conditions of service demand, there would, of course, be the same necessity for a Pressure-Retaining Valve, as with the Type P Triple Valve.

QUESTIONS

1069. What are the requirements of a brake apparatus?

1070. Wherein does the type L valve differ from the older equipments?

1071. What important feature does the type L valve possess?

1072. In what way is the high emergency pressure feature secured?

1073. What is the function of the supplementary reservoir?

1074. Describe in brief, the process of charging and release?

1075. How is service application accomplished?

1076. How is quick service brought about?

1077. Upon what does the amount of opening given the service port depend?

1078. If the reduction is so rapid that the quick service feature is no advantage, how does the graduating spring act?

TYPE L TRIPLE VALVE.

This triple valve has the usual brake-pipe auxiliary reservoir, and brake-cylinder connections, also an additional connection for a supplementary reservoir. Fig. 348 shows a view of the type L triple valve, with the safety valve in place. In order that trains may be controlled easily and smoothly when running at either high or low speeds, and that stops may be made quickly and with the least liability of wheel sliding, the brake apparatus must provide the following essential features of operation:

A small brake-pipe reduction must give a moderate brake-cylinder pressure and a moderate but uniform retardation on the train as a whole.

It must be possible to make a heavy service reduction quickly, but without liability of quick action.

It must be possible to graduate the release as well as the application of the brakes.

To insure the ability to obtain brake applications in rapid succession, and to full power, a quick recharging of the auxiliary reservoirs is necessary. This feature also enables the engineer to handle long trains in heavy grade work with a much greater factor of safety than heretofore, and eliminates the need for retaining valves.

For high-speed trains, a high brake-cylinder pressure available for emergency applications is imperative, in order to provide a maximum braking power, when the shortest possible stop is required to save life or to avoid sudden danger.

The Westinghouse Air Brake Co. claim that they have met the above requirements by the development of the type L triple valve. This triple valve is of the quick-action, automatic, "pipeless" type, and is intended for use only in high-speed passenger service. The L valve

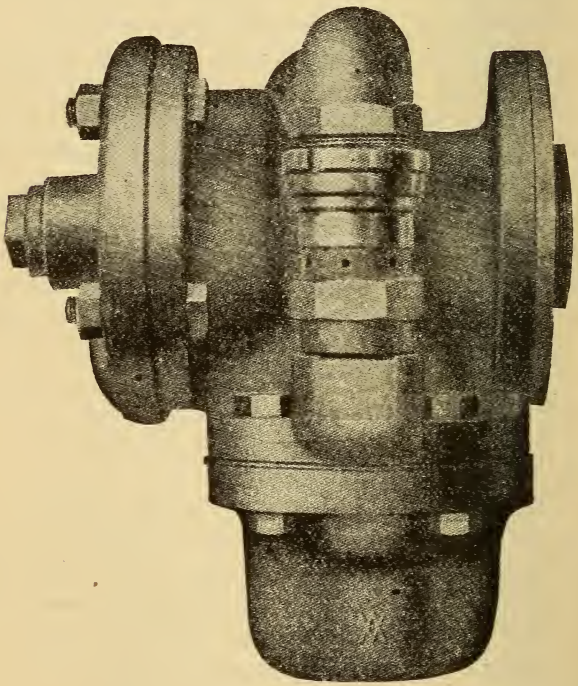


FIG. 348. THE TYPE L TRIPLE VALVE

forms a part of the LN Passenger Car Equipment, which is designed throughout to meet the service conditions outlined above. Being of the quick action type it possesses the following important features:

1st. Quick Recharge (of auxiliary reservoirs), by which a rapid recharging of the brake system is secured, thus making it possible to obtain full braking power immediately after a release has been made and permitting as many applications and releases in quick succession as may be desired, without materially depleting the system.

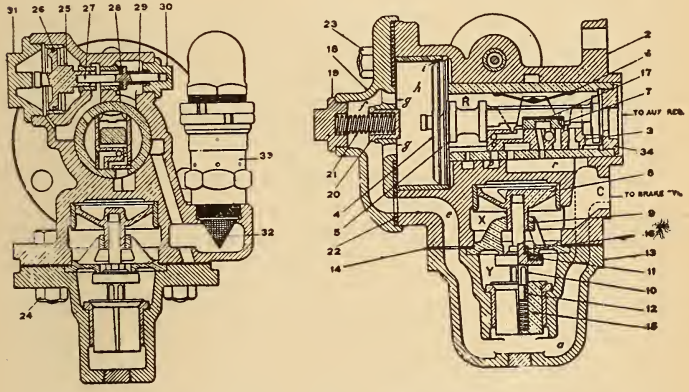


Fig. 349. THE TYPE L TRIPLE VALVE

2nd. Quick Service, by which a very quick serial *service* action of the brakes throughout the train is secured, similar to that in emergency applications, but less in degree. This makes certain the prompt and uniform application of all the brakes in the train, correspondingly increasing the rapidity and effectiveness of any given brake-pipe reduction, and thereby practically eliminating the need for the harsher emergency application, except in cases of actual danger.

3rd. Graduated Release, which permits of partially or entirely releasing the brakes on the entire train at will.

4th. High Emergency Cylinder Pressure, which

greatly increases the available braking power in emergency applications over the maximum obtainable with a full service reduction. With this, as with all quick-action triple valves, a portion of the air contained in the brake pipe is vented to the brake cylinder in emergency applications, thus providing for the quick serial operation of the brakes in the usual way. This, in itself increases the brake cylinder pressure thus obtained, considerably above the maximum pressure, possible in ordinary service applications.

The high emergency pressure feature referred to still further increases this emergency pressure, and the high cylinder pressure thus obtained, is retained without reduction, until released.

This is accomplished by the use of a supplementary reservoir in addition to the ordinary auxiliary reservoir. The supplementary reservoir is approximately double the size of the auxiliary reservoirs. Its function is to assist in obtaining the graduated release of the brakes, and the high emergency cylinder pressure, and the way in which this is accomplished will be explained later on. This feature makes it possible to use the equipment as a high speed brake, when carrying 90 lbs. brake pipe pressure, and obtain better results than when using 110 lbs. pressure with the old standard equipment in steam road service. Fig. 349 shows a vertical cross section of the valve, and the names of its various parts are as follows:

2, Valve Body; 3, Slide Valve; 4, Piston; 5, Piston Ring; 6, Slide Valve Spring; 7, Graduating Valve; 8, Emergency-Valve Piston; 9, Emergency-Valve Seat; 10, Emergency-Valve; 11, Rubber Seat for Emergency-Valve; 12, Check-Valve Spring; 13, Check-Valve Case; 14, Check-Valve Case Gasket; 15, Check Valve; 16,

Emergency Valve Nut; 17, Graduating-Valve Spring; 18, Cylinder Cap; 19, Graduating-Spring Nut; 20, Graduating Sleeve; 21, Graduating Spring; 22, Cylinder Cap Gas-

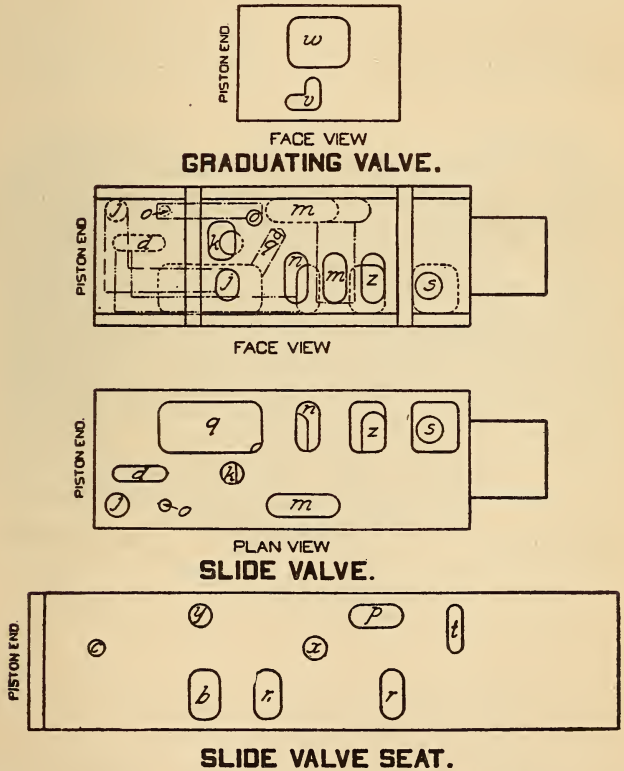


FIG. 350. GRADUATING VALVE, SLIDE VALVE, AND SLIDE-VALVE SEAT. TYPE L TRIPLE VALVE

ket; 23, Bolt and Nut for Cylinder Cap; 24, Bolt and Nut for Check-Valve Case; 25, By-Pass Piston; 26, By-Pass Piston Ring; 27, By-Pass-Valve; 28, By-Pass-Valve

Seat; 29, By-Pass-Valve Spring; 30, By-Pass Valve Cap; 31, By-Pass-Piston Cap; 32, Strainer; 33, E-7 Safety Valve.

Fig. 350 illustrates the actual arrangement of ports, and cavities, in the graduating valve, slide valve, and slide valve seat, of the type L triple valve. Owing to the impossibility of showing all of the ports and con-

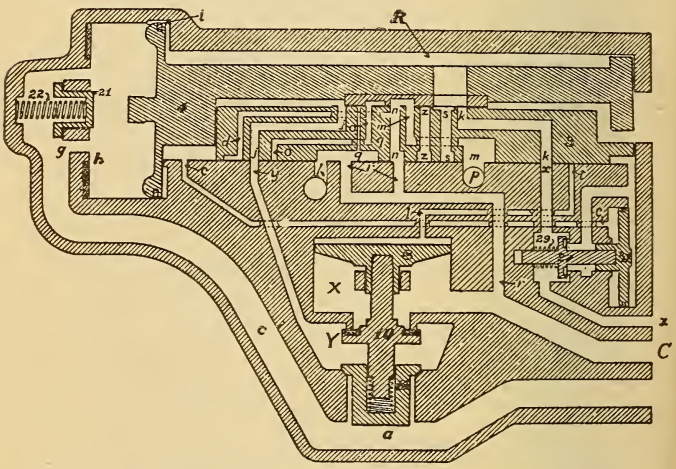


FIG. 351. FULL RELEASE AND CHARGING POSITION

necting passageways in any single illustration, figures 352, 353, 354, 355 and 356, are presented, and each shows in a diagrammatic way, the relations of the various parts to each other, for the different positions of the triple-valve piston.

The actual proportions and mechanical construction of the parts have been disregarded, in order to make the connections, and operation more intelligible to the student. The letters designating the ports and passages appear-

ing on Figures 349 to 356 inclusive, correspond throughout, but the reference numbers on Fig. 349 do not exactly correspond with those on the diagrammatic views. The various connections shown in Fig. 349, and the ports in Fig. 350 will, however, be made clear, by comparison with the diagrammatic views shown in Figures 351 to 356. Referring to Fig. 350, it will be noticed that the

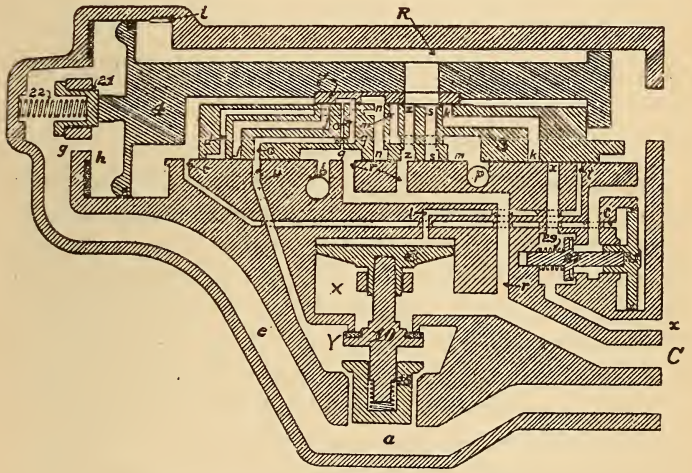


FIG. 352 QUICK-SERVICE POSITION

ports in the plan view of the slide valve seat are as follows: r leads to the brake cylinder; t, to the top of the emergency piston; p, to exhaust; x, to the supplementary reservoir; y, to the check valve case and chamber Y; b, to the safety valve, and c, to the space behind the by-pass piston.

The registration of the parts is most readily followed, and understood, by reference to, and comparison with

the diagrammatic drawings, Figures 351 to 356, in which the connections to the triple valve are as follows:

a—Brake Pipe.
x—Supplementary Reservoir.
C—Brake Cylinder.
p—Exhaust.
b—Safety Valve.
R—Auxiliary Reservoir.

OPERATION OF THE TYPE L TRIPLE VALVE.

CHARGING.

Referring to Figures 349 and 351, air from the brake pipe enters the triple valve through the passages a, e, g, and h, to the face of the triple valve piston (which is then forced to release position as shown), thence through the feed groove *i* to chamber R and auxiliary reservoir. Brake-pipe air in passage *a* also raises the check valve 15, and entering chamber Y flows thence through the ports *y* and *j* into chamber R and the auxiliary reservoir. This check valve then prevents any back flow of air from the auxiliary reservoir to the brake pipe. At the same time, port *k* registers with port *x* and the air in chamber R also flows through these ports into the supplementary reservoir. Both the auxiliary and supplementary reservoirs are thus charged at the same time and to the same pressure from the brake pipe through the two different channels already mentioned. When in this position, air from the brake cylinder, entering the triple valve at C, flows through passage *r*, port *n*, large cavity W (Fig. 350), in graduating valve, and ports *m*, and *p*, to the atmosphere, thus releasing the brakes.

SERVICE APPLICATION.

The ports of the triple valve being in release, and charging as shown in Fig. 351, a service reduction in brake-pipe pressure, reduces the pressure in chamber *h*, and on the face of the triple valve piston, below that in the auxiliary reservoir on the opposite side of the piston.

The higher auxiliary reservoir pressure therefore forces the piston in the direction of the lower brake-pipe pressure, carrying with it the attached graduating valve. The first movement of the piston closes the ports *j*, *m* and *k*, thus shutting off communication between the brake pipe, and the auxiliary and supplementary reservoirs, and closing the exhaust passage from the brake cylinder to the atmosphere. The same movement opens port *z* and connects ports *q* and *o*, in the main slide valve through the small cavity *v* in Fig. 350 in the graduating valve. The spider or lugs on the end of the piston stem, then engage the end of the main slide valve, which is carried along with the piston, and graduating valve, as the reduction continues. This brings the parts into quick service position shown in Fig. 352.

Service port *z* in the slide valve, registers with brake cylinder port *r*, in the seat, thus allowing the air in the auxiliary reservoir to flow to the brake cylinder, and apply the brakes. At the same time the quick service ports, *o* and *q*, and the small cavity *v*, in the graduating valve, connect passage *y* leading from chamber Y in the check valve case with passage *r* leading to the brake cylinder. This allows air from the brake pipe to lift the check valve, and flow through the above mentioned ports to the brake cylinder. This constitutes the quick service action of the triple valve, in that it causes a slight, but

definite reduction in brake pipe pressure locally, at each valve. The effect of a reduction in brake-pipe pressure, made at the brake valve, is thus quickly and uniformly transmitted from car to car throughout the train. The amount of air vented from the brake pipe to the quick service ports is not great for two reasons; first, because the ports and the passage ways are small; second, because in the movement of the slide valve 3 to full

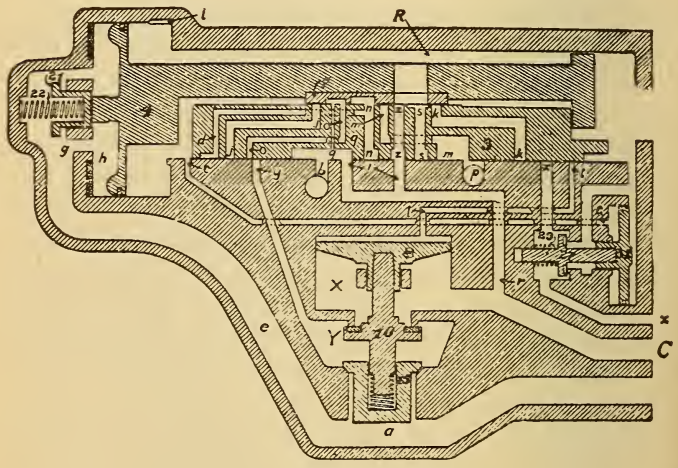


FIG. 353. FULL-SERVICE POSITION

service position, the quick service port *y* is restricted as it approaches this position and completely closed just before service port *z* is fully open, as shown in Fig. 353.

The amount of opening given the service port in any case, depends upon the rate of reduction in brake pipe pressure as compared with that of the auxiliary reservoir.

If the former is at first rapid, as compared with the

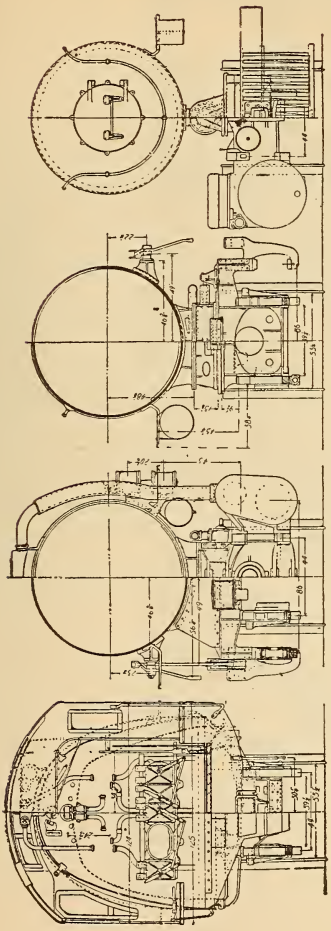


FIG. 346. MALLET ARTICULATED COMPOUND LOCOMOTIVE—BALTIMORE & OHIO RAILROAD—WALSCHAERT VALVE GEAR

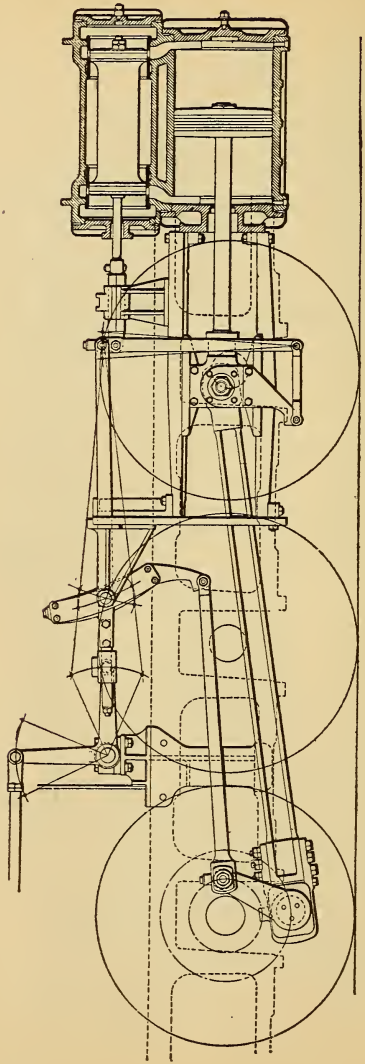


FIG. 347. WALSCHAERT VALVE GEAR AS APPLIED TO CONSOLIDATION FREIGHT LOCOMOTIVES—LAKE SHORE & MICHIGAN SOUTHERN RAILWAY

QUESTIONS

1037. From what two points is motion transmitted to the valve by the Walschaert valve gear?

1038. From what point are the two important factors of lap and lead imparted?

1039. What advantage is derived from the crosshead connection as regards lead?

1040. How may the movements of the valve as operated by this gear be diagrammatically illustrated?

1041. Mention an important feature of the Walschaert valve gear as regards adjustment.

1042. How is the combination lever of the Walschaert gear proportioned relative to the piston stroke?

1043. What kind of link is used with this valve gear, and how should it be located relative to the length of the radius bar?

1044. At what point is the radius bar attached to the combination lever for outside admission valves?

1045. At what point is this connection made for inside admission valves?

1046. Where should the fulcrum of the link be located?

1047. Where should the suspension point of the link be located?

1048. What should be the minimum length of the eccentric rod, relative to the throw of the eccentric?

1049. What rule should be observed regarding the point of connection of the eccentric rod to the link?

1050. In what position should the link be when the piston is at either end of the stroke?

1051. What is the chief point of difference between the Walschaert and the Stephenson valve motions?

1052. How are the factors of lap and lead determined?

1053. In the adjustment of the Walschaert valve gear, what position should the crank be first placed in?

1054. Before changing the length of the eccentric rod, what precaution should be observed regarding the valve rod?

1055. What is the second rule to be observed in the adjustment of this motion?

1056. Mention the third maxim for guidance in this adjustment.

1057. Give the fourth rule relative to the adjustment of this gear.

1058. According to the fifth rule, how may the lead be increased?

1059. What effect does increasing the lead have upon the cut-off?

1060. What is the sixth proposition relative to the adjustment of the Walschaert valve gear?

1061. Can the location of the link and eccentric rod be determined by formula?

1062. How then can these important points be found?

1063. How is the location for the suspension point of the lifter determined?

1064. Upon what two factors does the success of the Walschaert valve gear depend?

1065. Are the valve movements in actual practice as

regular as the circles in the Reauleaux, and Zeuner diagrams indicate?

1066. Give some reasons for this discrepancy.

1067. How may many of the irregularities due to the angularities of the main rod and eccentric rod be largely modified?

1068. How does the Walschaert valve gear compare with the Stephenson link motion as regards weight?

THE OHIO LOCOMOTIVE INJECTOR.

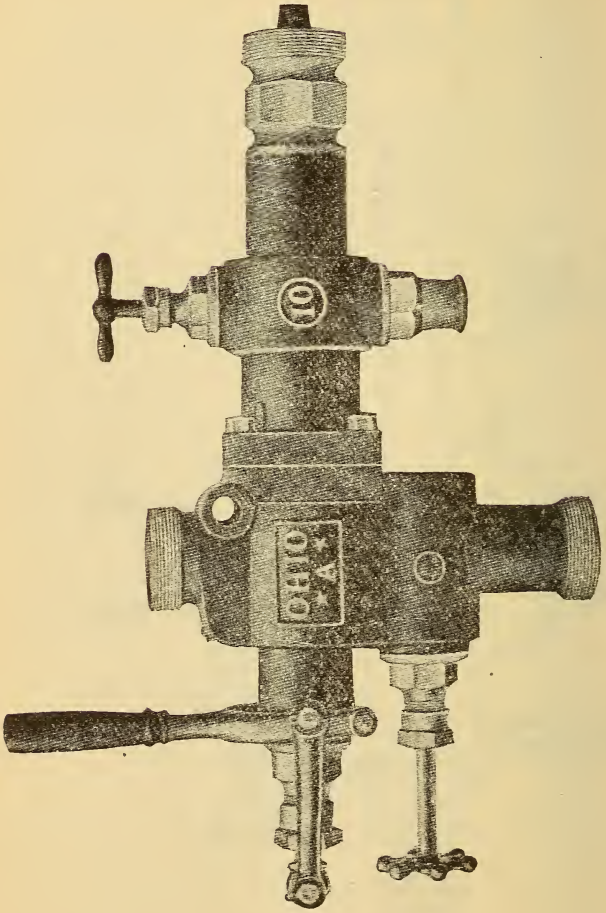
Type.—The Ohio Injector as shown is a simply constructed lifting injector. It lifts and forces the water with one set of tubes placed in a center line through the body of the injector.

Description.—As shown in the sectional cut are the following parts:

1—Body (back part).
2—Body (front part).
3—Delivery end connection.
4—Steam valve hub complete.
5—Steam valve and primer complete.
6—Steam nozzle.
7—Lifting tube.
8—Combining tube.
9—Delivery tube.
10—Line check valve.
11—Stop ring.
12—Overflow valve complete.
13—Water valve complete.
14—Starting lever.
15—Overflow nozzle.

The steam pipe leading from the dry steam space of the boiler is connected to the top of the injector above steam valve 5. The water or suction pipe is connected to the bottom of the injector below water valve 13. The branch or delivery pipe is coupled to the delivery end connection in front of line check valve 10, and stop ring

OHIO LOCOMOTIVE INJECTOR.
Sectional View.



OHIO LOCOMOTIVE INJECTOR
Lever Movement

11. The overflow nozzle 15 should be fitted with a drain pipe leading to some convenient place outside of the ash pan.

To Operate—First pull the starting lever 14 back until the resistance of primer is felt. As soon as full volume of water appears at the overflow, pull starting lever back as far as it will go.

Regulate the quantity of water needed by the water valve. When operating the injector the steam pressure should be turned full into the steam pipe, as this governs the working of the injector.

When the steam valve 5 is in priming position, the inside priming nozzle is seated against the steam nozzle 6; this permits the steam to pass into the priming nozzle through the small ports, back of the seat, and to pass out through the contracted opening at the point of priming nozzle. As the steam leaves the priming nozzle it passes into the lifting tube 7; from lifting tube 7 the steam passes into combining tube 8, from which it passes through spill holes to the chamber surrounding the tubes. From this chamber the steam passes out through overflow valve 12 and nozzle 15 into the atmosphere.

The rush of steam passing from the point of the priming nozzle into lifting tube 7, causes a partial vacuum to be formed in the chamber in front of water valve 13. The partial vacuum acting in combination with the atmospheric pressure on the water in the tank causes the water to rush up into the injector body and follow the rush of steam out of the overflow to the atmosphere. The starting lever 14 is pulled full back. The full jet of steam traveling at a high velocity mingles with the water and is condensed by it; the resultant mixture then has a

velocity, and pressure greater than the boiler pressure, which causes the water to be forced into the boiler.

To use as heater: close the overflow valve 12, and pull lever 14 back until the resistance of the primer is felt, and let stand at this point. Overflow valve 12 must not be closed except when injector is to be used as a heater.

Important points in applying and operating the Ohio Injector. The pipes should be the specified sizes for each size of injector. Keep the tank valve open wide; keep all joints tight; keep hose strainers clean; keep packing in good condition.

Working pressure and capacity. The Ohio Injector works under steam pressure from 250 lbs. down to 25 pounds. The capacities are regulated according to size.

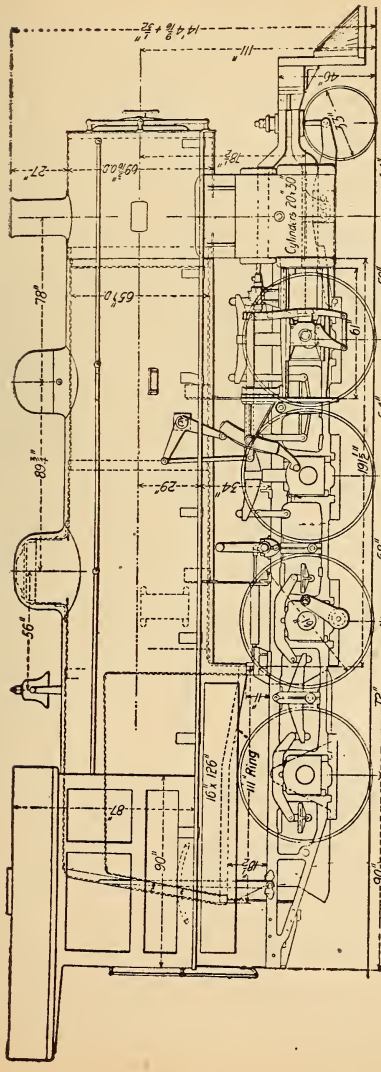


FIG. 339. WALSCHAERT VALVE GEAR—CONSOLIDATION FREIGHT LOCOMOTIVE—BOSTON & MAINE RAILROAD

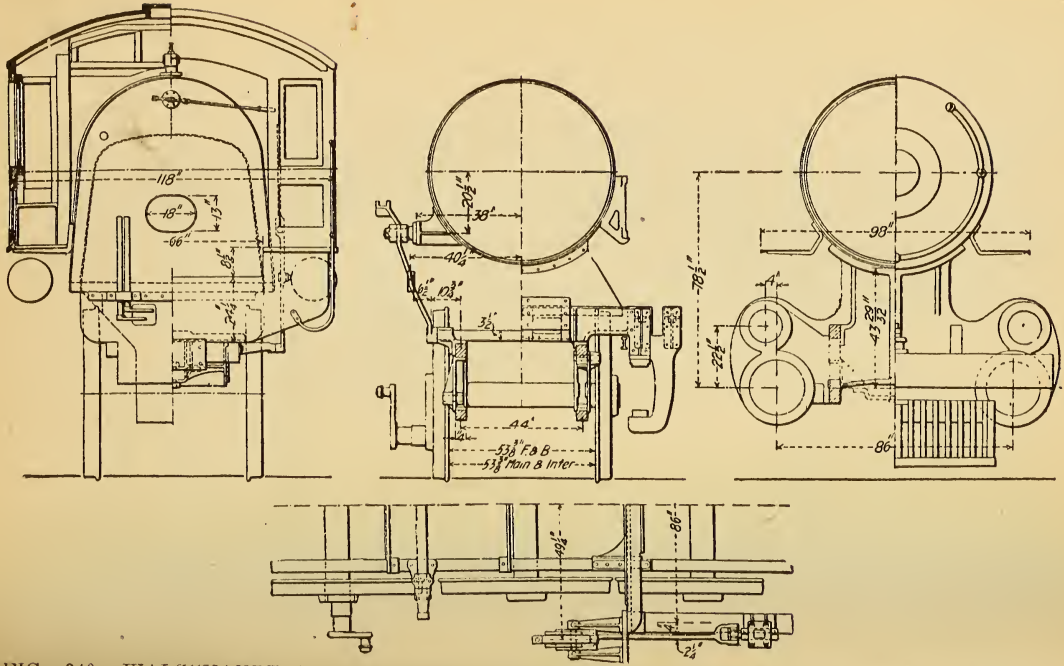


FIG. 340. WALSCHAERT VALVE GEAR—CONSOLIDATION FREIGHT LOCOMOTIVE—BOSTON & MAINE RAILROAD

points R, R^1, R^2, R^3, etc. On OH we have the full travel valve circle and OL the lap or radius of the lap circle, the latter being the same for all cut-offs, as well as the lead, the radii H^1, H^2, H^3, etc., of the eccentric circles or diameters of the corresponding valve circles terminate on a line HI drawn perpendicular to AB, and at a distance from O equal to that of lap and lead.

When the reverse lever is in its center position the diameter of the valve circle falls on the line AB, and is equal to lap and lead. Continuing in back position we have the same method repeated and OI would be the full travel valve circle diameter, or the same as the eccentric radius for the valve travel. Any desired cut-off position may be laid out in the same manner as that in Fig. 336, which shows all the valve movements for a complete revolution of the axle.

The movements are in actual practice not so regular as the circles indicate, as it is impracticable to obtain the various loci in their theoretical positions; besides, we have the angularities both of the main rods and the eccentric rods to contend with, and whereby irregularities are entering in the problem that must be compensated for, as referred to in the general description. It is not to be considered that a uniform circular motion is the best, but an approximation to it works with fewer shocks or jerks, and is therefore more desirable for so high-speed an engine as a locomotive. A few advantages can be taken, however, in selecting the suspension, and various connections, so that better results can be obtained than from a true circular motion, which are principally affected by three union points and are, first, the connecting point of eccentric rod and link; second, the locus of the lifting link suspension point; and third, the relative height of

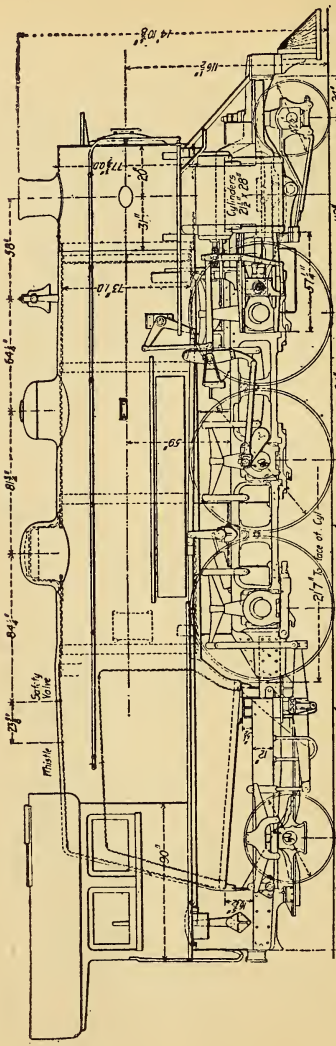


FIG. 341. WALSCHAERT VALVE GEAR—PRAIRIE TYPE PASSENGER LOCOMOTIVE—PENNSYLVANIA RAILROAD

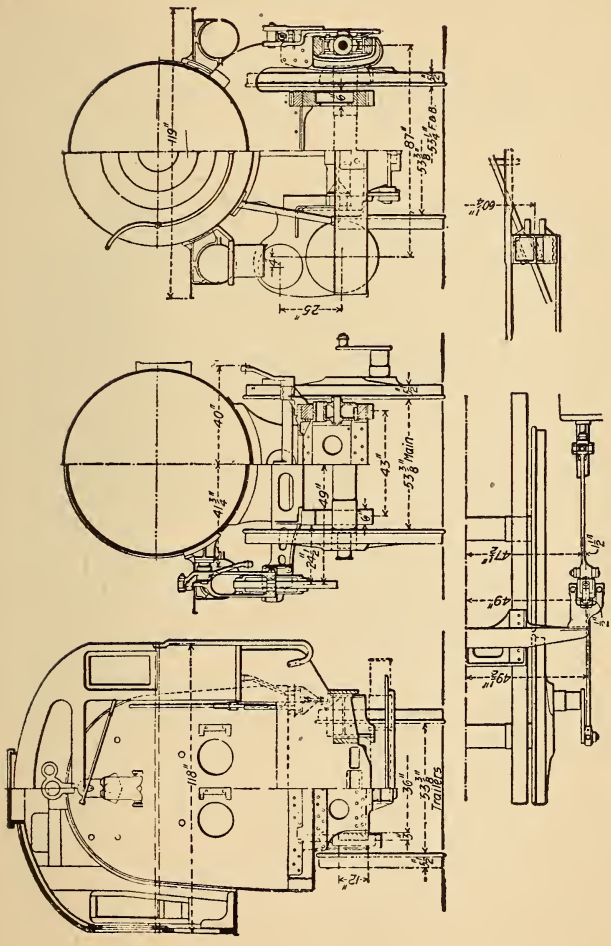


FIG. 342. PRAIRIE TYPE PASSENGER LOCOMOTIVE—PENNSYLVANIA RAILROAD—WALSCHAERT VALVE GEAR

the crosshead connection point of the union bar, to the corresponding point of the combination lever.

It is not necessary to lay out the valve diagrams except where a given cut-off per cent is wanted. This is the most convenient way to find the required lap.

WEIGHT OF WALSCHAERT GEAR.

In the matter of weights of parts, the details, in pairs, of the Walschaert gear of this engine (Lake Shore & Michigan Southern 2-8-0 type No. 912) are as follows: Crosshead arms, 60 pounds; vibrating rods, 220 pounds; eccentric rods, 220 pounds; links, 260 pounds; transmission bars, 140 pounds; valve rods, 70 pounds; eccentric cranks, 100 pounds; vibrating links, 70 pounds; valve stems, 72 pounds; and transmission bar hangers, 72 pounds. This means a total weight of 1,252 pounds for the entire valve gear of the Lake Shore engine, not including the valves. The weight of the corresponding valve gear parts of a recently constructed 20 x 28-inch, 4-6-0 engine, with Stephenson link motion, is 2,734 pounds. Such a weight, which must be moved and reversed for every revolution, imposes severe duty upon the eccentrics, and it is not surprising that they heat.

SAVING IN WEIGHT WITH WALSCHAERT VALVE GEAR.

COMPARATIVE WEIGHTS, STEPHENSON AND WALSCHAERT VALVE GEAR.

Lake Shore & Michigan Southern Locomotives.

	CLASS AND TYPE					
	CLASS D, 2-8-0		CLASS J, 2-6-2		CLASS J, 2-6-2	
	Stephenson	Walschaert	Stephenson	Walschaert	Stephenson	Walschaert
Crank pins, main	520	490	390	365	440	415
Crank pin arms	.....	100	.....	80	.....	90
Crosshead arms	.....	60	.....	50	.....	50
Eccentric	600	.....	740	.....	740	.....
Eccentric strap	800	.....	880	.....	1,120	.....
Eccentric rods	200	220	200	175	280	200
Link	280	260	260	240	300	275
Link support	.....	280	.....	250	.....	260
Link lifter	45	.....	120	.....	120	.....
Reverse shaft and arms	260	400	350	375	385	390
Rockers	260	.....	280	325	280	350
Rocker boxes	240	.....	300	300	300	325
Transmission bar	300	140	270	160	300	170
Transmission bar hanger	80	72	120	65	120	75
Transmission bar bracket	.....	.....	.....	.....	200	.....
Valve rod	80	70	130	100	100	100
Vibrating rod	.....	220	.....	180	.....	180
Vibrating link	.....	70	.....	60	.....	60
Total, lbs	3,665	2,382	3,940	2,725	4,685	2,940
Saving in weight, lbs		1,283		1,215		1,745

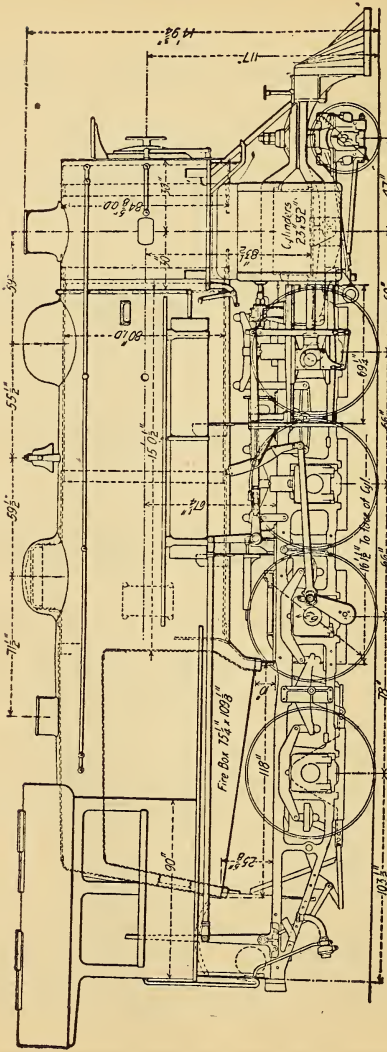


FIG. 343. CONSOLIDATION FREIGHT LOCOMOTIVE—NEW YORK CENTRAL & HUDSON RIVER RAILROAD—WALSCHAERT VALVE GEAR

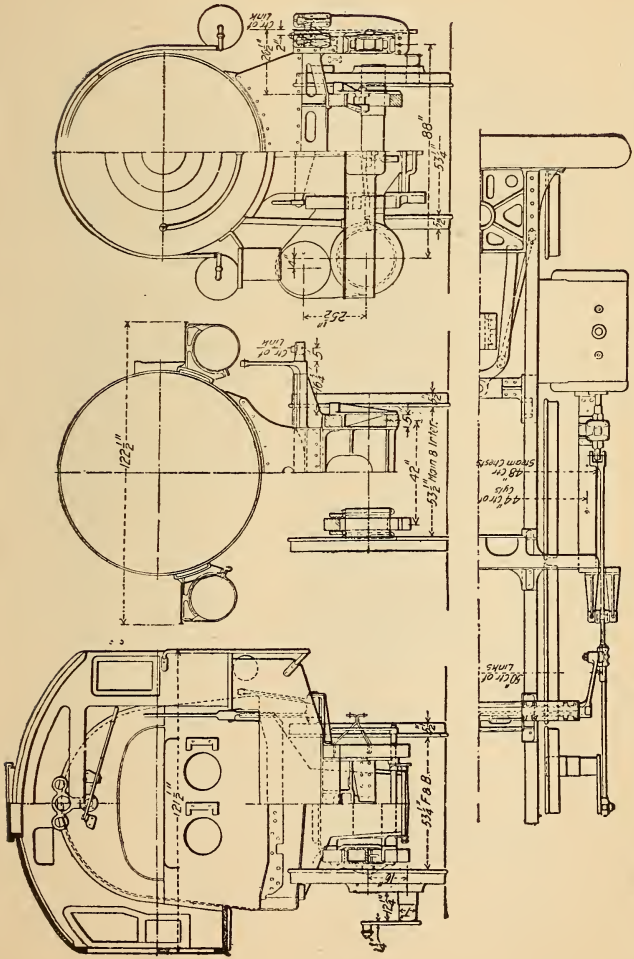


FIG. 344. WALSCHAERT VALVE GEAR—CONSOLIDATION FREIGHT LOCOMOTIVE —NEW YORK CENTRAL & HUDSON RIVER RAILROAD

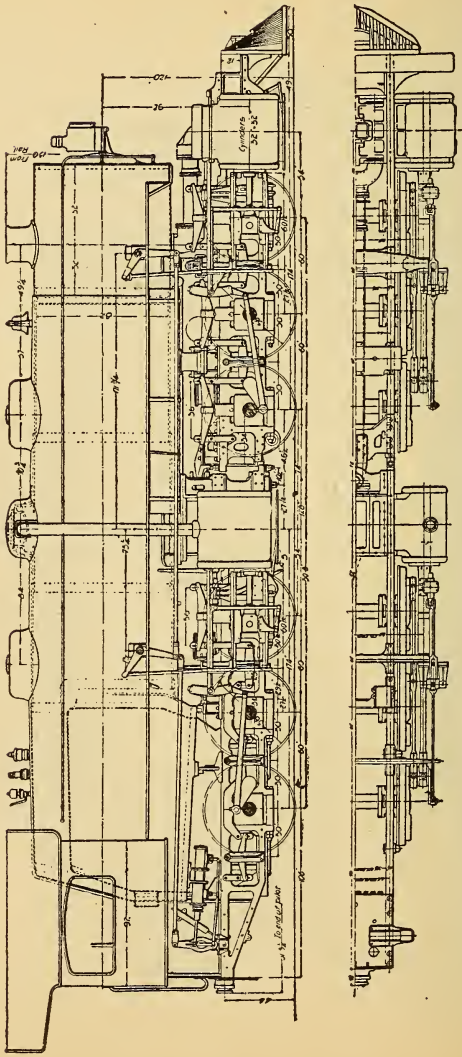


FIG. 345. WALSCHAERT VALVE GEAR—MALLET ARTICULATED COMPOUND FREIGHT LOCOMOTIVE—BALTIMORE & OHIO RAILROAD

For outside admission valves the radius bar is attached to the combination lever between the valve stem and the crosshead connections, and for inside admission (piston valves) it is attached above the valve stem. The fulcrum of the link should lie as nearly as practicable upon a line drawn through the union of the radius-bar and combination lever, parallel with the center line of the valve stem. The suspension point of the lifter should have a locus which causes the link block to travel as nearly as practicable on a chord of the arc described by any point of the link, wherever the block happens to be when the link is swung into one of its extreme positions.

This is most closely approached by a lifter through which the radius bar slides, and does not swing with the link. A properly suspended hanger will accomplish practically the same result, though the slip of the link bar will be somewhat more in the back than in the forward motion, but as the suspension point cannot be made to follow the theoretical locus, it should be made to do so as nearly as possible by favoring the position of the most commonly used cut-offs.

In locating the longitudinal position of the link fulcrum, consideration should also be given to the length of the eccentric rod, which should have a minimum length of 3½ times the eccentric throw, and should be made as long as circumstances will permit, with an approximate equal length of the radius and eccentric rods. The point of connection between the eccentric rod and the link should be as near the center line of motion of the main rod as this correction for rod angularities will permit, but this is often accompanied with the requirement of excessive eccentric throw. In such cases a compromise must be made to raise this point. The fore and aft position of this

point relative to the tangent of the link arc must also be determined with reference to the angularity of the eccentric and main-rods, so that the link is exactly in its central position when the piston is at either end of the stroke. The angles through which the link swings on both sides of its central position should be as nearly as practicable equal, but this is subordinate to other conditions. Attention should be paid to the effect of the angularity of the main connecting rod upon the cut-off, to reduce this to a minimum, this having an effect upon determining the locus of the suspension point of the lifting link, as well as that of the eccentric rod connection to the link.

It is evident that a proper design of Walschaert gear can only be laid out by a skilled draughtsman. In maintenance, care is required that all parts should preserve their original forms and position, and this should be checked by verifying the valve movements through turning the main driving wheels before the locomotive goes into service.

The chief point of difference between the Walschaert and Stephenson motions is that the former gives to the valve a constant lead at all cut-offs, whereas the latter produces an increase of lead which becomes excessive at short cut-offs.

METHOD OF ADJUSTING VALVES WITH WALSCHAERT GEAR.

The lap and lead are determined by the proportion of the arms of the combination lever and the stroke of the piston. The amount is found by turning the engine from one dead center to the other center in any cut-off position.

1. The motion must be adjusted with the cranks on

the dead centers, by lengthening, or shortening the eccentric rods until the link takes such a position as to impart no motion to the valve when the link block is moved from its extreme forward to its extreme backward position. Before this change in the eccentric rod is resorted to, the length of the valve stem should be examined, as it may be of advantage to plane off, or line under, the foot of the link support which might correct the lengths of both rods, or at least only one of these should need to be changed.

2. The difference between the two positions of the valve on the forward and back centers is the lap and lead doubled, and cannot be changed, except by changing the leverage relations of the combination lever.

3. A given lead determines the lap, or a given lap determines the lead, and it must be divided for both ends as desired, by lengthening or shortening the valve spindle.

4. Within certain limits this adjustment may be made by shortening or lengthening the radius bar, but it is desirable to keep the length of this bar equal to the radius of the links, in order to meet the requirements of the first condition.

5. The lead may be increased by reducing the lap, and the cut-off point will then be slightly advanced. Increasing the lap introduces the opposite effect on the cut-off. With good judgment these quantities may be varied to offset the irregularities inherent in transforming rotary into lineal motions.

6. Slight variations may be made in the cut-off points as covered by the previous paragraph, but an independent adjustment cannot be made except by shifting the location of the suspension point, which is preferably determined by a model.

METHOD OF LAYING OUT WALSCHAERT GEAR.

Having presented a general outline of the gear, we may proceed in determining the more important points necessary to obtain a successful motion of the valve, and, as previously stated, the stroke of the engine is given, and the travel, and lap and lead of the valve are selected to suit a desired cut-off. We have first to find the proportions of the combination lever. By designating the lap and lead with a letter C, the crank Radius with R, the crosshead end of the combination lever with *L*, and the valve end of the same with V, we have R:C=L:V, or $V=\frac{CL}{R}$, with the connection F of the radius bar as a fulcrum. The length of the combination lever must be determined from the height of the valve stem over the piston rod, and a convenient angle of oscillation of 45° to 50°, which should not exceed 60°.

We have next to find the required travel of point F, Fig. 333, to obtain the desired valve travel, which for convenience sake is taken on one side of the center position, or half its total travel in full gear, and which we will designate b, when we have:

$b=\frac{R\sqrt{a^2-c^2}}{R+c}$ for outside admission, and $b=\frac{R\sqrt{a^2-c^2}}{R-c}$ for inside admission valves, where a is the radius of an eccentric that would give the required travel of the valve, and c is as given above.

This may be laid out graphically as in Figs. 334 and 335, when *a* is equal to one-half the travel of the valve and R and *c* the same as in the above formulæ.

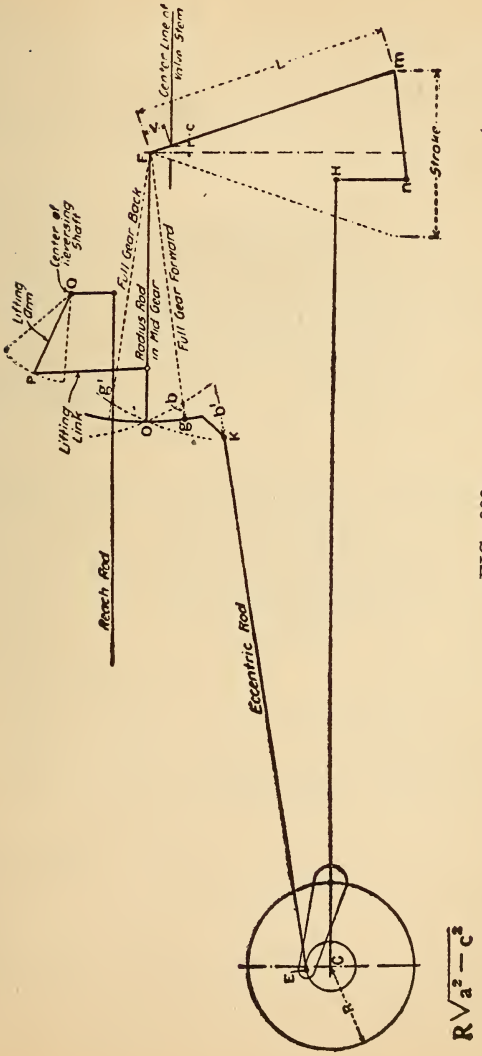

Center Line of Valve Stem
Full Gear Back
Radius Rod in Mid Gear
Full Gear Forward
Center of Reversing Shaft
Lifting Arm
Lifting Link
Reach Rod
Eccentric Rod
Stroke
$R\sqrt{a^2-c^2}$

FIG. 333

With the limited amount it is advisable to allow in raising or lowering the link block in reversing the motion, we can without practical error consider the half movement of the link block g to be the same as that of point F, and by limiting the angle of the swing of the

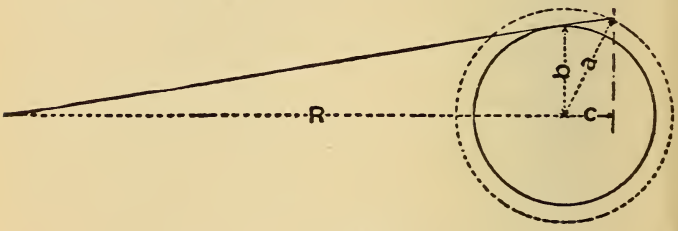


FIG. 334

link to a maximum of 45°, we get the raise or depression of the radius bar and link block $Og = \frac{b}{\tan. d}$, where O is the link fulcrum and d =half the angle of the swing of the link.

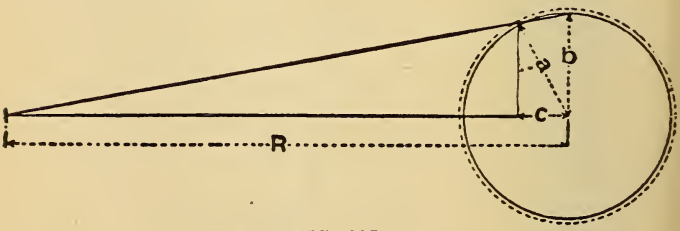


FIG. 335

The location of the link and eccentric rod connecting point K, Fig. 333, cannot be determined with any practicable formula, but must, as already stated, be found by plotting to meet the requirements of the different cut-

offs and corresponding crank positions. The same is also the case with determining the locus for the suspension point P of the lifting link, and in these two locations lies the principal success of the gear.

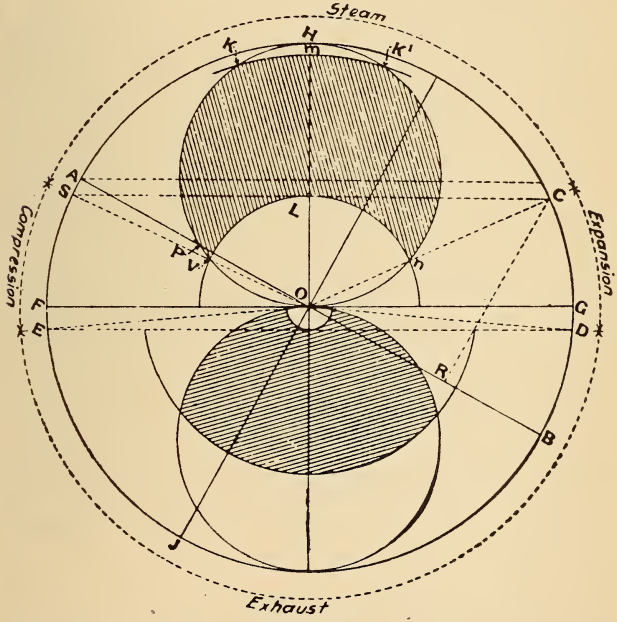


FIG. 336

THE REAULEAUX AND ZEUNER DIAGRAMS.

Figure 336 shows a combination of two diagrams, namely, those of Reauleaux and Zeuner, which coincide exactly as to the different valve movements, which may be found as follows:

The distance AB represents the travel of the valve as

well as the stroke of the engine, though in different scales, which makes no difference when the cut-off is always expressed in fractions or per cent of AB. The maximum cut-off is determined upon to be AR. Draw a perpendicular line RC from AB until it cuts the arc ACB. Next decide on a desired lead and, with that as a radius, draw an arc with A as a center. Draw a line from C tangent to the lead circle around A, when the lap of the valve is found to be equal to the perpendicular distance from the line CS to the center O of the diagram. The crank will then be in the position OS when the valve commences to open, or the angle AOS in advance of the dead center, and on OC at cut-off. Continuing, we find the valve in its middle position when the crank is on OG, which is drawn parallel to SC through the center O. Extend this line to F, and with the exhaust lap as a radius, draw the exhaust lap circle on the opposite side of the line GF, and draw DE tangent to this circle, when OD is the position of the crank at the release point. From this point the exhaust remains open until the crank reaches the position OE, when it closes, and compression takes place until it again reaches OS for admission, and one revolution is completed.

By placing the Zeuner diagram upon this, draw HJ perpendicular to FG, and with the radius OH of the eccentric circle as a diameter, draw the admission valve circle OVH*n*O, and the lap circle with the steam lap as a radius and find the intersection occurs at V, both with the circles and the previously laid down admission line OS, and the cut-off point at the intersections at *n*. On the line OH set off the width of the steam port from *L* toward H equal to L*m*, and with O*m* as radius draw the arc K*m*K. The shaded figure enclosed by the letters

VKK′nL represents the steam port opening during the admission period, and the width of the port opening at any desired position of the crank is found by measuring the distance radially from O between the lap and valve circles on the port line, as the case may be, on the desired crank position.

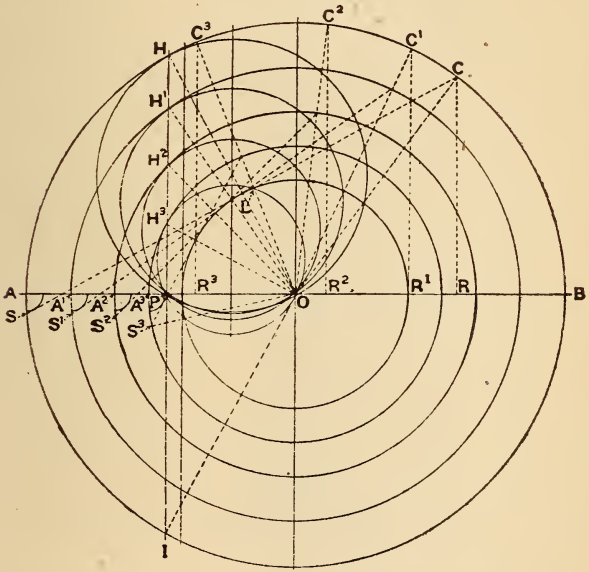


FIG. 337

The exhaust openings are determined in the same manner and are shown on opposite side of FG, where the crank passes through the arc DJE during the exhaust period, with a positive exhaust lap of the size EF. When the exhaust edge of the valve is line and line, this arc becomes GFJ, or 180°, and when a negative lap

(clearance) occurs, the duration of the exhaust period exceeds the half revolution of the crank. The various events are indicated around the eccentric circle on the figure as they take place during a complete turn of the crank.

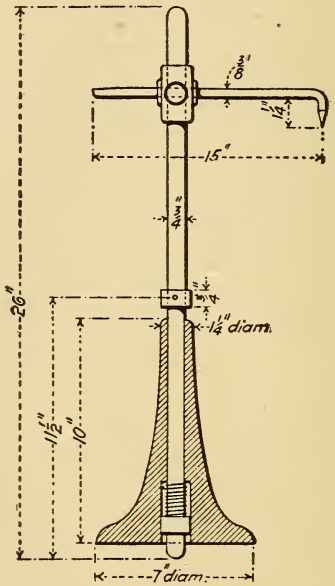


FIG. 338. A CONVENIENT GAUGE FOR SETTING THE ECCENTRIC CRANK

In Fig. 337 the eccentric and admission valve circles are shown at different cut-offs where each set of lines and circles is governed by the same explanation as those of Fig. 336, where the admission points S, $S,^1$ S^2, S^3, correspond to the closing positions C, C^1, C^2, C^3, cut-off

The latter is held in position by the retarding-device spring, 33. If the rate of increase of the brake-pipe pressure is small, as, for example, when the car is near the rear of the train, the triple valve parts will remain in this position, as shown in Fig. 326, the brakes will release and the auxiliary reservoirs recharge as described under

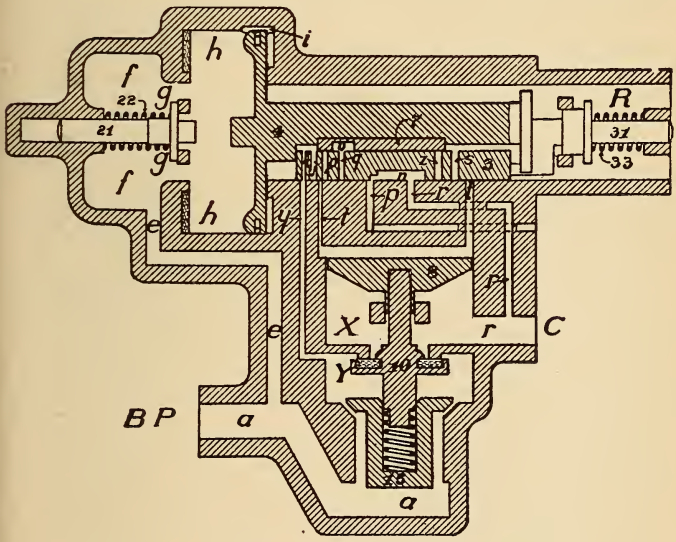


FIG. 330. RETARDED-RELEASE POSITION

"Full Release and Charging." If, however, the triple valve is near the head of the train, and the brake-pipe pressure builds up more rapidly than the auxiliary reservoir can recharge, the excessive pressure in chamber *h* will cause the piston to compress retarding-device spring, 33, and move the triple-valve parts to the position shown in Fig. 330.

Exhaust cavity *n* in the slide valve now connects port *r* leading to the brake cylinder, with port *p* to the atmosphere, and the brake will release; but as the small extension of cavity *n* (see Fig. 325) is over port *p*, discharge of air from the brake cylinder to the atmosphere is quite slow. In this way the brakes on the front end of the train require a longer time to release than those on the rear. This feature is called the "Retarded Release," and although the triple valves near the locomotive commence to release before those in the rear, as in the case with the H-triple valve, yet the exhaust of brake-cylinder pressure in retarded-release position is sufficiently slow to allow the rear brakes to release first. This permits of releasing the brakes on very long trains at low speeds without danger of a severe shock or break in two.

At the same time, the back of the piston is in contact with the end of the slide-valve bush and, as these two surfaces are ground to an accurate fit, their contact effectually cuts off communication between chambers *h* and R through feed groove *i*, preventing air from feeding through from the brake pipe to the auxiliary reservoir by this path. Also, port *l* in the slide valve registers with port *y* in the slide valve seat, and pressure in chamber Y can flow through ports *y* and *l* to the chamber R and the auxiliary reservoir. Chamber Y is supplied with air under these circumstances by the check valve 15 raising and allowing brake-pipe air to flow past it. The area of port *l* is about half that of feed groove *i*, so that the rate that the auxiliary reservoir will recharge is much less than when the triple valve is in the full-release position.

As the auxiliary-reservoir pressure rises, and the pressures on the two sides of piston 4 become nearly equal, retarding-device spring 31 forces the piston, slide valve,

graduating valve, and retarding device stem back to the full release position shown in Fig. 326, when the remainder of the release and recharging will take place as described above under "Full Release and Charging."

These features of the new valve are always available, even when mixed in trains with the old standard, the beneficial results being in proportion to the number of new valves present.

EMERGENCY POSITION.

Emergency Position is the same with the K triple valve as with the H type. Quick action is caused by a sudden and considerable reduction in brake-pipe pressure, no matter how caused. This fall in brake-pipe pressure causes the difference in pressures on the two sides of piston 4 to increase very rapidly, so that the friction of the piston, slide valve and graduating valve is quickly and greatly overcome, and they move to the left with such force that when the piston strikes the graduating stem, it compresses graduating spring 22, forcing back the stem and spring, until the piston seats firmly against the gasket 23, as shown in Fig. 331. The movement of the slide valve opens port *t* in the slide-valve seat, and allows auxiliary reservoir pressure to flow to the top of emergency piston 8, forcing the latter downward and opening emergency valve 10. The pressure in chamber Y, being instantly relieved, allows brake-pipe air to raise the check valve 15 and flow rapidly through chambers Y and X to the brake cylinder, until brake-cylinder, and brake-pipe pressures equalize, when both check valve and emergency valve are forced to their seats by the spring in the former, preventing the air in the cylinders from escaping back into the

brake pipe again. At the same time port *s* in the slide valve registers with port *r* in the slide-valve seat, and allows auxiliary-reservoir pressure to flow to the brake cylinder. But the size of ports *s* and *r* is such that very little air gets through them before the brake pipe has stopped venting into the brake cylinder. This sudden discharge of brake-pipe air into the brake cylinder has the same effect on the next triple valve as would be caused

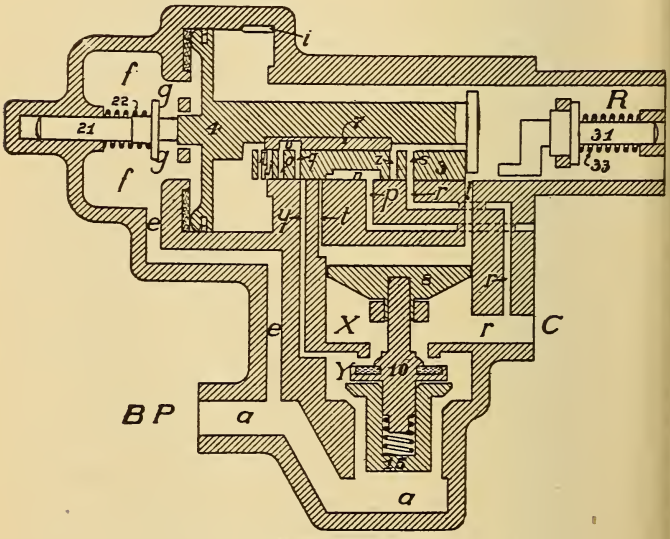


FIG. 331. EMERGENCY POSITION

by a similar discharge of brake-pipe air to the atmosphere. In this way each triple valve applies the next, thus giving the quick and full application of all brakes, made heavier than full service application through the greater amount of brake-pipe air admitted to the brake cylinders.

The rapidity with which the brakes apply throughout the train is so much increased, that in a 50-car train it requires less than three seconds; the brake-cylinder pressure is also increased approximately twenty per cent.

The release after an emergency is effected in exactly the same manner as after a service application, but requires a longer time, owing to the higher brake-cylinder pressures and lower brake-pipe pressures.

To change a standard type H triple valve to the type K, it is necessary to add the retarded-release feature, and to make the necessary changes in the controlling valves, body, and check-valve case.

MANIPULATION.

No special instructions are required by the engineers to handle trains partially, or wholly fitted with the K triple valve. The automatic brake valve should be handled as good practice requires with the H triple valve. Some of the most important details are as follows:

Make the terminal brake tests, and check the results indicated by noting how well the brakes hold in the first running application, and be governed accordingly in subsequent applications.

Before attempting to release have an ample excess pressure for the length of train, and in releasing leave the handle of the automatic brake valve in release position until the rear brakes have had time to release.

As return to running position will cause triple valves in retarded-release position to change to full-release position, the brake-valve handle should not be moved from release too soon. However, with short trains the usual early return to running position will prevent unnecessary retardation of release.

QUESTIONS

1019. What are the principal advantages possessed by the Type "K Triple Valve over the older Types"?

1020. Describe the Quick service feature.

1021. How is this feature produced?

1022. What conditions are secured by the Retarded release feature?

1023. How are the auxiliary reservoirs uniformly recharged throughout the train?

1024. How many sizes of the K valve are at present made?

1025. How may the K-2 valve be distinguished from the K-1?

1026. Mention the principal disadvantages attending a service application with the ordinary quick action triple valve.

1027. Are these conditions present with the K Triple Valve?

1028. Describe briefly full service position.

1029. What conditions are present with lap position?

1030. How are the two release positions of the K Triple Valve designated?

1031. What conditions control the position of full release?

1032. How is retarded release accomplished?

1033. Is there any difference in emergency position, whether with the K Triple Valve, or with the H Type?

1034. What length of time is required for an application throughout a train of 50 cars with the K Triple Valve?

1035. What changes are necessary to convert a type H Triple Valve to Type K?

1036. What are three important rules to be observed by engineers in the handling of trains partially, or wholly equipped with the K Triple Valve?

WALSCHAERT VALVE GEAR—GENERAL DESCRIPTION.

The motion of the valve, as shown in Fig. 332 is derived both from the crosshead, and the eccentric crank from a driving axle. The crosshead connection imparts the lap and lead at the extremities of the stroke, when the eccentric crank is in its middle position. The eccentric crank in this position imparts its fastest movement to the valve to give a very quick opening. The crosshead motion in advancing from the dead point effects an approximate uniformity in the combined motion given to the valve, as if it was derived from a single crank or eccentric set with an angle of advance corresponding to the lap and lead. The valve motion may therefore be graphically illustrated in the same manner as that of the Stephenson motion, with a circle representing the path of the eccentric, the diameter of which is equal to the travel of the valve, and the valve movements may be determined in the same way by any of the well-known methods of Professor Zeuner and others, as illustrated on another page. It will be observed that the only apparent variation due to this gear is that brought about by the invariable lead.

The Walschaert motion, as usually constructed, does not lend itself as freely to adjustment as does the Stephenson motion with independent eccentrics, and for this reason it is not as liable to get out of adjustment. It must be correctly laid out in the design and correctly fitted up. The importance of this cannot be overestimated. The

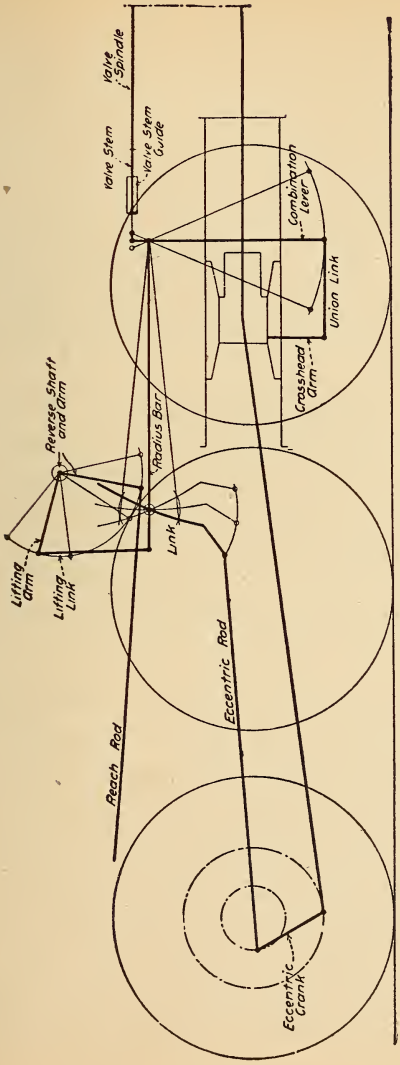


FIG. 332. OUTLINE OF WALSCHAERT VALVE GEAR AS APPLIED TO COMPOUND LOCOMOTIVE—BALTIMORE & OHIO RAILROAD

various points must be carefully plotted in order to give the best results in the combination movement of the parts of the motion. The movements of the motion involve such complications in plotting as to render the complete plotting of all too laborious for every new design, and for this reason the use of an adjustable model is very desirable in designing this gear. However, with complete knowledge of the nature of the gear, simple methods and formulæ may be used to determine the locations of the various points covering the motion. One object of this description is to avoid the necessity of a model except to verify the results.

To entirely overcome the irregularities inherent in all motions transformed from circular into lineal, cannot for practical reasons be expected, but the errors may be reduced to such an extent that they do not affect either the power or economy of the locomotive. This remark is made to forestall the inference that the accuracy of the Walschaert motion as to the cut-off points is not superior to the Stephenson motion when the latter is turned out of the shop.

In the construction of the Walschaert gear the desired travel of the valve, the lead and the maximum cut-off which determines the lap of the valve, are selected. The stroke of the piston being given, the combination lever is proportioned so that a motion equal to the lap and lead is given to the valve when the crosshead is moved from one end of the stroke to the other. The link may be made of any approved design, and is so located that the radius bar will have a length of at least eight times (ten or twelve times is better) the travel of the link block, and the radius of the link should be equal to the length of the radius bar.

over the emergency valve 10, and under the emergency piston 8. Also, it leads through port *r* to the seat under slide valve 3 (Fig. 325). The emergency piston 8 and the parts below it are the same as in the older quick-action freight triple valve. Port *y* (shown by dotted lines) connects chamber Y, between check valve 12 and emergency valve 10, with port *y* in the valve seat (Fig. 325).

Port *t* connects the slide-valve seat with the chamber above emergency piston 8. Port *p* is the exhaust port to the atmosphere. Port *j* in the slide valve begins at the face, as shown by the top view, Fig. 325, and passes around other ports in the valve to a smaller opening in the top. (NOTE:—This port *j* does not exist in the K-1 Triple Valve, as will be explained later.) Port *o* is similarly arranged, except that openings in top and bottom are alike in size. Port *q* runs directly through the slide valve, but is smaller at the top than at the face of the valve, and the smaller part is out of center with the larger part. Ports *s* and *z* run through the valve and connect with cavities in the face; port *z* also has a cavity at the top.

The face view of the graduating valve shows that it has a small cavity *v*. This valve is of the slide-valve type, and it seats on the top of the slide valve, where it controls the upper ends of ports *z*, *q*, *o* and *j*. The purpose of the cavity *v* is to connect the upper ends of ports *o* and *q* in a service application, as explained in detail later.

As shown by the face view of the slide valve, *n* is a long cavity having a narrow extension at the right hand end. This cavity connects the ports through which the air escapes from the brake cylinder in releasing. Port

b is cut diagonally from the face till it just cuts into the edge, at the top of the slide valve. It admits auxiliary-reservoir pressure to port *t* in an emergency application.

With this explanation, and by occasional reference from the diagrammatic views, to those in Fig. 325, the same ports being lettered alike, a clear understanding will be obtained of both the operation and actual arrangement of ports of the triple valves.

FULL RELEASE AND CHARGING POSITION.

Fig. 326 is a diagrammatic view of the triple valve in this position. Air from the brake pipe flows through passage *e,* cylinder cap *f,* and ports *g* to chamber *h;* thence through feed groove *i,* now open, to chamber R above the slide valve, which is always in free communication with the auxiliary reservoir. The feed groove *i* is of the same dimension as that of the old standard H-1 (F-36) triple valve, which is designed to properly charge the auxiliary reservoir of an 8-inch brake cylinder, and prevent any appreciable amount of air from feeding back into the brake pipe from the auxiliary reservoir during an application. For this reason, the feed groove of the K-2 triple valve is made the same size as the K-1, so that it is necessary in the K-2 triple, to increase the charging port area, through which the air can feed into the auxiliary reservoir, sufficiently to enable it to handle the greater volume of the auxiliary reservoir of a 10-inch brake cylinder. In order to do this, the small port *j* is added to the slide valve of the K-2 triple valve only; this port registers with port *y* in the slide-valve seat, when in the full release position. Air then passes from chamber Y, through ports *y* and *j* to chamber R, and the aux-

iliary reservoir. Brake-pipe air in *a* raises check valve 15 and supplies chamber Y with air as fast as it is required. Port *j* is so proportioned that the rate of charging the auxiliary reservoir of a 10-inch brake cylinder is made practically the same as that of the 8-inch, which in full

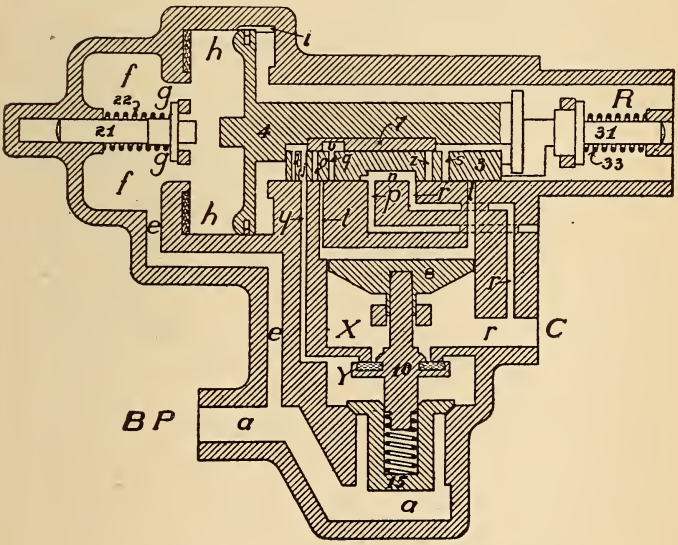


FIG. 326. FULL-RELEASE AND CHARGING POSITION

release is fed through the feed groove *i* only. In the following description, the K-2 triple valve only is referred to; the operation of the K-1 is exactly the same except for the absence of port *j*.

Air flows from the brake pipe to the auxiliary reservoir until their pressures become equal, when the latter is then fully charged.

QUICK-SERVICE POSITION.

To make a service application of the brakes, air pressure is gradually reduced in the brake pipe, and thereby in chamber *h*. As soon as the remaining pressure in the

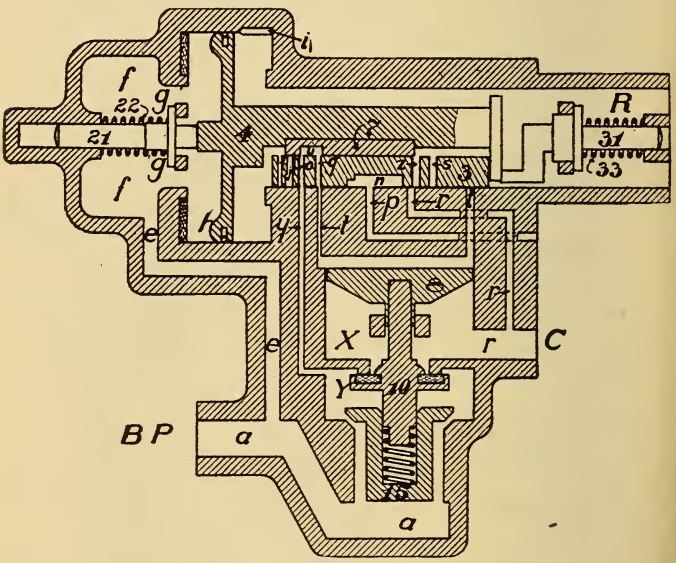


FIG. 327. QUICK SERVICE POSITION

auxiliary reservoir and chamber R becomes enough greater than that in chamber *h*, to overcome the friction of the piston 4 and graduating valve 7, these two move to the left until the shoulder on the end of the piston stem strikes against the right-hand end of the slide valve, when it also is moved to the left until the piston strikes the graduating stem 21, which is held in its place by the compression of the graduating spring 22. The parts of the valve are then in the position shown in Fig. 327.

The first movement of the graduating valve closes the feed groove *i*, preventing air from feeding back into the brake pipe from the auxiliary reservoir, and also opens the upper end of port *z* in the slide valve, while the movement of the latter closes the connection between port *r* and the exhaust port *p*, and brings port *z* into partial registration with port *r*, in the slide valve seat. Auxiliary-reservoir pressure then flows through port *z* in the slide valve, and port *r* in the seat to the brake cylinder.

At the same time, the first movement of the graduating valve connected the two ports *o* and *q* in the slide valve, by the cavity *v* in the graduating valve, and the movement of the slide valve brought port *o* to register with port *y* in the slide-valve seat, and port *q* with port *t*. Consequently, the air pressure in chamber Y flows through ports *y*, *o*, *v*, *q* and *t*, thence around the emergency piston 8, which fits loosely in its cylinder, to chamber X and the brake cylinder. When the pressure in chamber Y has reduced below the brake-pipe pressure remaining in *a*, the check valve raises, and allows brake-pipe air to flow by the check valve and through the ports above mentioned to the brake cylinders. The size of these ports is so proportioned that the flow of air from the brake pipe to the top of emergency piston 8, is not sufficient to force the latter downward, and thus cause an emergency application, but at the same time takes considerable air from the brake pipe, thus increasing the rapidity with which the brake-pipe reduction travels through the train.

With the ordinary quick action triple valve in a service application, all of the brake-pipe reduction has to be made at the brake valve, and the resulting drop in pressure passes back through the train at a rate depend-

ing on its length, size of brake pipe, number of bends and corners, etc., which cause friction and resistance; also a much heavier application of head than of rear brakes is caused at the beginning of the application, thereby running the slack in, which is liable at low speeds to be followed by the slack running out suddenly when the rear brakes do apply, causing loss of time and difficulty in making quick slow downs and accurate stops, and, with very long trains, results in such serious losses through leakage grooves, and feed grooves as to lose much braking power and even prevent some brakes from applying. With this new triple valve, only a small part of the reduction is made at the brake valve, while each triple acts momentarily as a brake valve to increase the reduction under each car, thereby rendering the resistance and friction in the brake pipe of much less effect, and hastening the application throughout the train. This is called the "Quick-Service" feature, and by means of it the rapidity of a full service application on a 50-car train is increased about fifty per cent. The rapid reduction of brake-pipe pressure moves the main piston 4 quickly to the service position, and cuts off any flow back from the auxiliary reservoir through the feed groove to the brake pipe; it rapidly drives the brake-cylinder piston beyond the leakage groove, and prevents loss of air through it; and yet permits applying with as moderate a brake force as desired. It also greatly reduces the brake-pipe reduction necessary at the brake valve for a certain brake-cylinder pressure, due to the fact (1) that part of the reduction takes place at each triple valve, and (2) that the air taken from the brake pipe into the brake cylinder gives a little higher pressure than if the auxiliary-reservoir pressure alone were admitted, thus re-

quiring a smaller brake-pipe reduction for the same cylinder pressure.

FULL-SERVICE POSITION.

With short trains, the brake-pipe volume, being comparatively small, will reduce more rapidly for a certain reduction at the brake valve than with long trains.

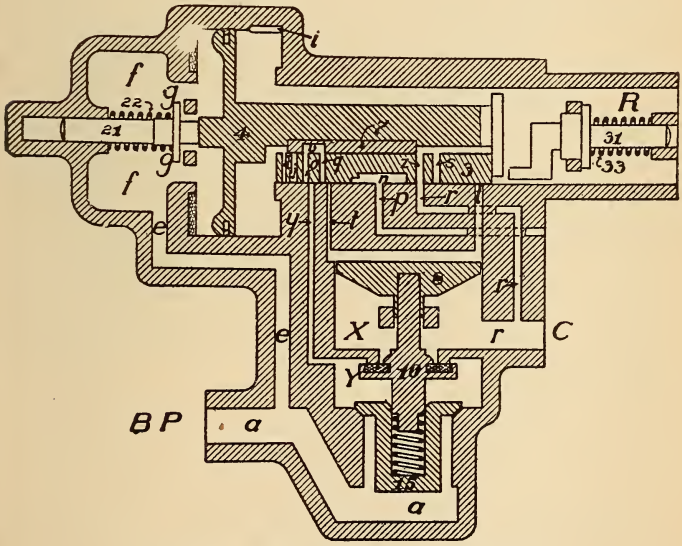


FIG. 328. FULL SERVICE POSITION

Under such circumstances the added reduction at each triple valve by the quick-service feature, might bring about so rapid a brake-pipe reduction as to cause quick action and an emergency application, when only a light application was intended. (The emergency application is explained later.) But this is automatically prevented

by the triple valve itself. From Fig. 327 it will be noted that in the quick-service position, port *z* in the slide valve and port *r* in the seat do not fully register. Nevertheless, the opening is sufficient to allow the air to flow from the auxiliary reservoir to the brake-cylinder with sufficient rapidity to reduce the pressure in the auxiliary reservoir as fast as the pressure is reducing in the brake pipe, when the train is of considerable length. But if the brake-pipe reduction is more rapid than that of the auxiliary, the difference in pressures on the two sides of piston 4 soon becomes sufficient to slightly compress the graduating spring, and move the slide valve to the position shown in Fig. 328, called *"Full Service."* In this position, quick service port *y* is closed, so that no air flows from the brake pipe to the brake cylinder; the brake-pipe reduction being sufficiently rapid, there is no need of the additional quick-service reduction, so the triple valve cuts it out. Also, ports *z* and *r* are fully open, and allow the auxiliary-reservoir pressure to reduce more rapidly, so as to keep pace with the more rapid brake-pipe reduction.

LAP POSITION.

When the brake-pipe reduction ceases, air continues to flow from the auxiliary reservoir through ports *z* and *r* to the brake cylinder, until the pressure in the chamber R becomes enough less than that of the brake pipe to cause piston 4, and graduating valve 7 to move to the right until the shoulder on the piston stem strikes the left-hand end of slide valve 3. As the friction of piston and graduating valve is much less than that of the slide valve, the difference in pressure which will move the piston and

the graduating valve, will not be sufficient to move all three; consequently, the piston stops in the position shown in Fig. 329. This movement has caused the graduating valve to close port *x*, thus cutting off any further flow of air from the auxiliary reservoir to the brake cylinder. Consequently, no further change in air pressures can occur, and this position is called "Lap," because all ports are *lapped*,—that is, closed.

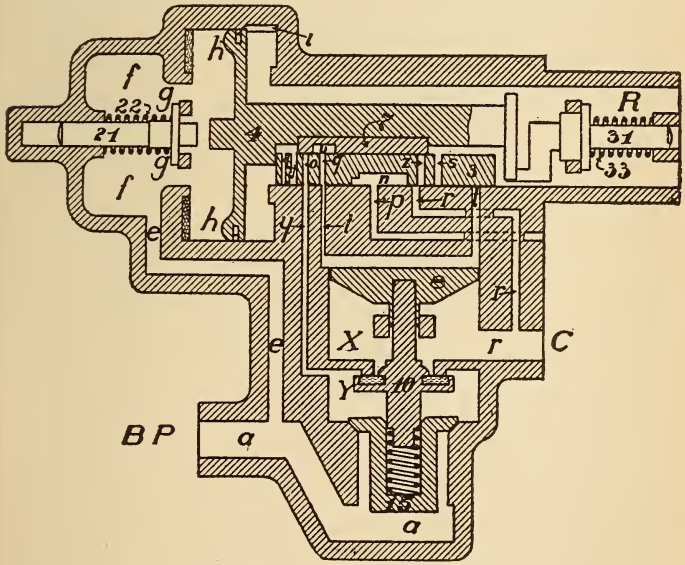


FIG. 329. LAP POSITION

If it is desired to make a heavier application, a further reduction of the brake-pipe pressure is made, and the operation described above repeated, until the auxiliary reservoir and brake cylinder pressures become equal,

after which any further brake-pipe reduction is only a waste of air. About twenty pounds brake-pipe reduction will give this equalization.

RETARDED RELEASE AND CHARGING POSITION.

The K triple valve has two release positions, full-release and retarded-release. Which one its parts will move to when the train brakes are released, depends upon how the brake-pipe pressure is increased; if slowly, it will be full release, and if quickly and considerably, it will be retarded-release. It is well known that in a freight train, when the engineer releases the brakes, that the rapidity with which the brake-pipe pressure increases on any car depends on the position of the car in the train. Those cars towards the front, receiving the air first will have their brake-pipe pressure raised more rapidly than those in the rear. With the old standard apparatus, this is due to two things: (1) the friction in the brake pipe; (2) the fact that the auxiliary reservoirs in the front at once begin to recharge, thus tending to reduce the pressure head by absorbing a quantity of air, and holding back the flow from front to rear of the train. The retarded-release feature of this new triple valve overcomes the second point mentioned, taking advantage of the first while doing so. The friction of the brake pipe causes the pressure in chamber *h* to build up more rapidly on triple valves towards the front than those in the rear. As soon as its pressure is enough greater than the auxiliary-reservoir pressure, remaining in chamber R after the application above described, to overcome the friction of piston, graduating valve, and slide valve, all three are moved toward the right until the piston stem strikes the retarding-device stem, 31.

992. What pressures are carried for high speed brake service?

993. Under these conditions, what pressure is attained in the application chamber?

994. What conditions are necessary to cause the parts of the valve to assume the position known as emergency lap?

995. What is the purpose of the double-heading pipe connection?

996. Describe the action of the safety valve.

997. How is this valve adjusted, and for what pressure?

998. In what respect does type H automatic brake valve differ from previous types?

999. When should the handle be kept in running position?

1000. What does service position give?

1001. For what purpose is lap position used?

1002. What is the purpose of release position?

1003. What results follow, when the valve is placed in holding position?

1004. Explain the difference between running and holding position.

1005. When is emergency position used?

1006. Of what type is the independent brake valve?

1007. In what position should this valve be carried when not in use?

1008. Describe the service position of this valve.

1009. When is lap position used for the independent brake valve?

1010. When is release position used?

1011. What type of valve, and for what purpose is the feed valve?

1012. Describe the construction and operation of the reducing valve.

1013. Describe the construction and operation of the pump governor.

1014. What is the "Dead Engine Feature"?

1015. Of what parts does it consist?

1016. How is the air for operating the brakes on a dead engine supplied?

1017. Describe briefly the route that the air takes under such conditions.

1018. What is the function of the strainer?

THE "DEAD ENGINE" FEATURE.

The "Dead Engine" feature shown in Fig. 295 is for the operation of the locomotive brakes when the pump on a locomotive in a train is inoperative through being broken down, or by reason of no steam. Fig. 322 shows the combined strainer, check valve, and choke fitting. As these parts are not required at other times, a cut-out cock is provided. This cock should be kept closed except under the conditions just mentioned. The air for operating the brakes on such a locomotive must then be supplied through the brake pipe from the locomotive operating the train brakes.

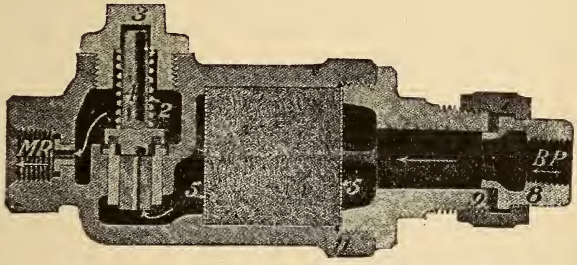


FIG. 322. COMBINED AIR STRAINER AND CHECK VALVE

With the cut-out cock open, air from the brake pipe enters at BP, Fig. 322, passes through the curled hair strainer, lifts check valve 4, held to its seat by a strong spring, passes through the choke bushing, and out at MR to the main-reservoir, thus providing pressure for operating the brakes on this locomotive. The double-

heading cock should be closed, and the handle of each brake valve should be in running position. Where absence of water in the boiler, or other reason, justifies keeping the maximum braking power of such a locomotive lower than the standard, this can be accomplished by reducing the adjustment of the safety valve on the distributing valve. It can also be reduced at will by the independent brake valve.

The strainer protects the check valve and choke from dirt. Spring 2 over the check valve insures this valve seating and, while assuring an ample pressure to operate the locomotive brakes, keeps the main-reservoir pressure somewhat lower than the brake-pipe pressure, thereby reducing any leakage from the former. The choke prevents a sudden drop in brake-pipe pressure and the application of the train brakes, as would otherwise occur with an uncharged main reservoir cut in to a charged brake pipe. In this, it operates similarly to the feed groove in a triple valve.

THE TYPE "K" FREIGHT TRIPLE VALVE.

Modern conditions have created new braking problems. The old and well-known (Type H) quick-action freight triple valve was designed to meet the requirements of the time when 50-car trains, 30-ton capacity cars, and moderate speeds were maximum conditions. But the increased train lengths, speeds, and car capacities of the present day, have demanded certain modifications to meet these, and anticipated, requirements.

The Westinghouse Air Brake Company has developed and perfected a new Quick-Action Freight Triple Valve, designated as Type "K," which facilitates train move-

ments, increases the factor of safety in handling trains, and reduces damage to lading and equipment, in so far as they are affected by air-brake operation.

The K triple valve embodies every feature of the old type, and in addition three new ones called the *Quick-Service, Retarded Release* and *Uniform Recharge.* It not only works in perfect harmony with the old valves, but greatly improves the action of the latter when they are mixed in the same train. They have many parts in common, are interchangeable, and the old can be converted into the new without the loss of many parts.

The *Quick-Service* Feature, which produces a quick serial operation of the brakes in service applications, has been obtained by utilizing the well known principle of quick-action in emergency applications, by which each triple valve augments the brake-pipe reduction by discharging brake-pipe air into its brake cylinder. The essential difference is that in emergency, the maximum braking power is always obtained with both the old and new valves, while with the new valve, the power of its quick-service application is always under complete control, and is governed by the reduction made at the brake valve. The result is that the quick-service feature insures the prompt and reliable response of every brake; eliminates the undesirable use of emergency applications where a flag, an unforeseen danger ahead, or the need of making an accurate stop, frequently necessitates such an application with the old standard freight-brake equipment; reduces the possible loss of air due to flowing back through the feed grooves from the auxiliary reservoir to the brake pipe, or by the leakage grooves in the cylinders; and gives a more uniform application of the brakes throughout the train.

The *Retarded-Release* Feature, which insures practically a *simultaneous* release of all brakes, has been effected by automatically restricting the exhaust of air from the brake cylinders at the head end of the train, and allowing all others to release freely. To obtain this result requires merely the usual correct method of operating the brake valve, the retarded release being due to the quick and considerable rise in brake-pipe pressure which the release position of the brake valve can cause for about 25 or 30 cars from the locomotive.

The *Uniform Recharge* of the auxiliary reservoirs throughout the train is obtained by the fact that when the triple valve is in retarded-release position, the charging ports between brake pipe and auxiliary reservoir are automatically restricted. As long as the release of brake-cylinder exhaust is retarded, the recharge is restricted, and since the one feature depends upon the other, the restricted recharge operates only on the first twenty-five or thirty cars back of the engine, the remaining brakes recharging normally, thus insuring practically a simultaneous recharge of all brakes in the train. This feature not only avoids the overcharge of the auxiliary reservoirs on the front cars and the subsequent undesired reapplication of their brakes, but by drawing less air from the brake pipe permits the increase in brake-pipe pressure to travel more rapidly to the rear for releasing and recharging those brakes.

The new valve is at present manufactured in two sizes, the "K-1" for use with 8-inch freight-car brake cylinders, corresponding with the H-1 (F-36), and the "K-2" with 10-inch freight-car brake cylinders, corresponding with the H-2 (H-49). The K-1 will bolt to the same reservoir as the F-36, and the K-2 as the H-49. Each valve

is marked with its designation on the side of the valve body, and the K-2 may be distinguished from the K-1 by the fact that it has *three,* as compared with *two,* bolt holes in the reservoir flange. Also, in order to distinguish the type K valves from the old standard type, their exterior being similar when they are attached to the

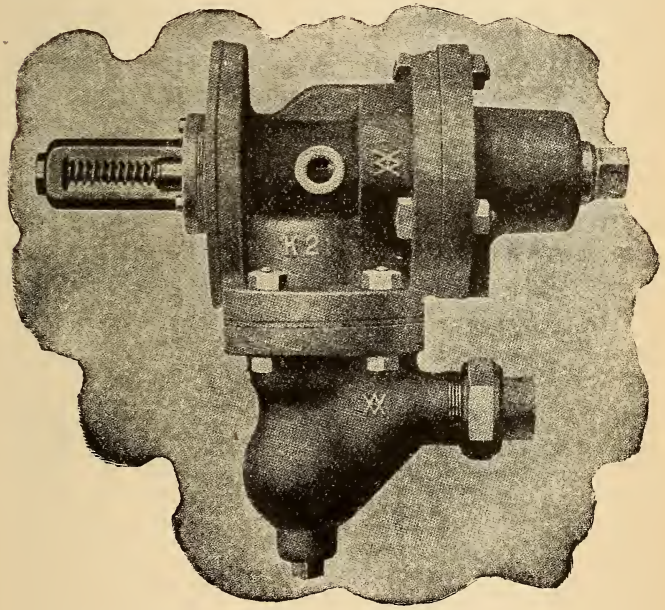


FIG. 323. THE TYPE "K" FREIGHT TRIPLE VALVE

auxiliary reservoir, a lug is cast on the top of the valve body, as shown in Fig. 323. This enables anyone to locate them at once.

Fig. 324 is a vertical cross section of this valve, and the names of the various parts are as follows:

2, Valve Body; 3, Slide Valve; 4, Piston; 5, Piston-Packing Ring; 6, Slide-Valve Spring; 7, Graduating Valve; 8, Emergency Piston; 9, Emergency-Valve Seat; 10, Emergency Valve; 11, Emergency-Valve Rubber Seat; 12, Check-Valve Spring; 13, Check-Valve Case; 14, Check-Valve-Case Gasket; 15, Check Valve; 16, Air Strainer; 17, Union Nut; 18, Union Swivel; 19, Cylinder Cap; 20, Graduating-Stem Nut; 21, Graduating Stem;

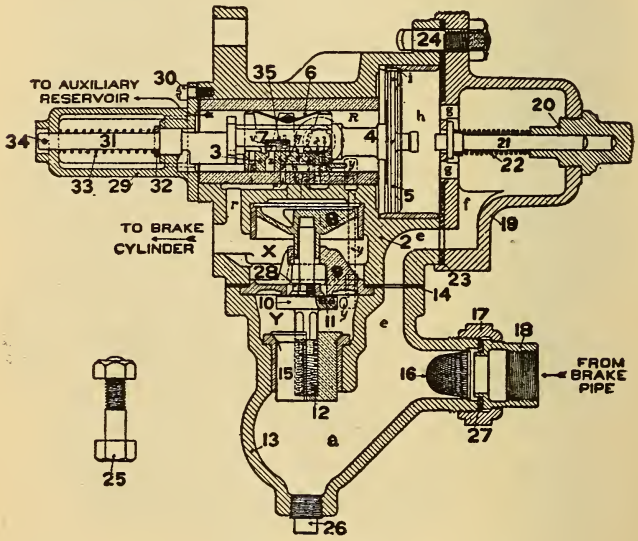


FIG. 324. THE K-2 TRIPLE VALVE

22, Graduating Spring; 23, Cylinder-Cap Gasket; 24, Bolt and Nut; 25, Triple-Valve Cap Screw; 26, Drain Plug; 27, Union Gasket; 28, Emergency-Valve Nut; 29, Retarding-Device Bracket; 30, Retarding-Device Screw; 31, Retarding-Device Stem; 32, Retarding-Device

Washer; 33, Retarding-Device Spring; 34, Retarding-Device-Stem Pin; 35, Graduating-Valve Spring.

Figure 325 shows the relative position of the ports and cavities in the slide valve, graduating valve, and slide-valve seat of the K-2 Triple Valve. As it is difficult to show all of these in a single section, diagrammatic cuts of the valve in each of the principal positions have been used, all ports and passages having been so arranged as to place them in one plane. In preparing these cuts, the actual proportion, and mechanical construction of the valve has been disregarded for the purpose of making the connections of ports, and operation, more easily understood.

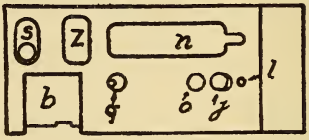
EXPLANATION OF FIGURES 324 AND 325.

Referring to Figure 324, the branch from the brake pipe connects at union swivel 18. The retarding-device bracket 29 projects into the auxiliary reservoir, and by its construction free communication exists between the auxiliary reservoir and chamber R, in which the slide-valve 3 and graduating valve 7 operate. The retarding-device stem 31, through its extension into chamber R, and the action of its spring 33, forms the stop against which the stem of piston 4 strikes when it moves to the release position (from right to left in the cut, it being shown in full-release position).

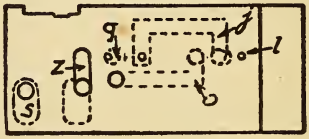
The opening marked "To Brake Cylinder" comes opposite one end of the tube which leads through the auxiliary reservoir to the brake cylinder, when the valve is bolted in place on the end of the auxiliary reservoir. This opening in the triple valve leads to chamber X

FACE VIEW

GRADUATING VALVE.

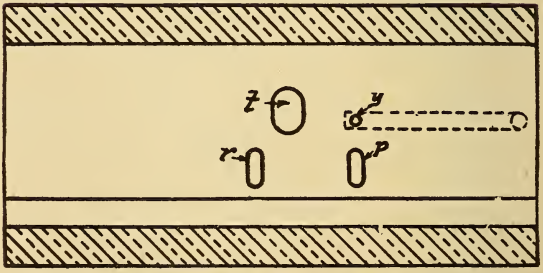


FACE VIEW



TOP VIEW

SLIDE VALVE.



SLIDE VALVE BUSH.

FIG. 325. SLIDE VALVE, GRADUATING VALVE, AND SLIDE-VALVE SEAT OF K-2 TRIPLE VALVE

a, a to the supply-valve chamber B, forcing supply-valve piston 8 to the left, compressing piston spring 6 and causing supply valve 10 to open port *c,* permitting the air to pass through ports *c* and *d* to the feed-valve pipe at delivery, and through port *e* to diaphragm chamber L.

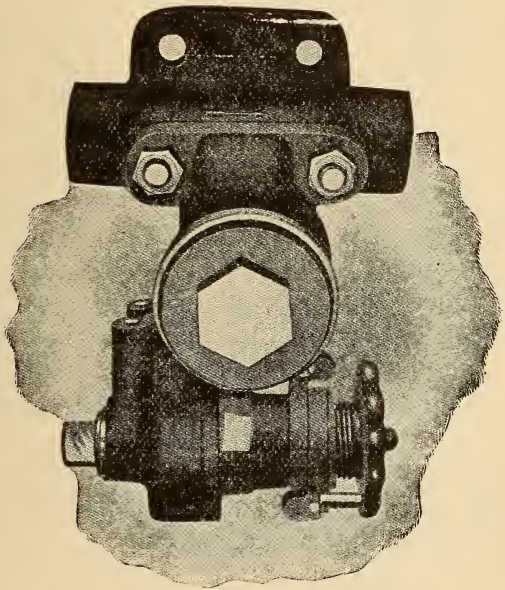


FIG. 317. FEED VALVE

At the same time air flows through port *f* in supply-valve piston 8 to chamber G, and through port *h* to regulating-valve chamber H. As regulating-valve 13 is raised from its seat, it will flow through port *k* to chamber L. When the feed-valve-pipe pressure, which is always present in chamber L against the dia-

piragm, exceeds the pressure of regulating spring 18, the diaphragm will yield and permit the regulating valve 13 to be forced to its seat, closing port *k* and cutting off

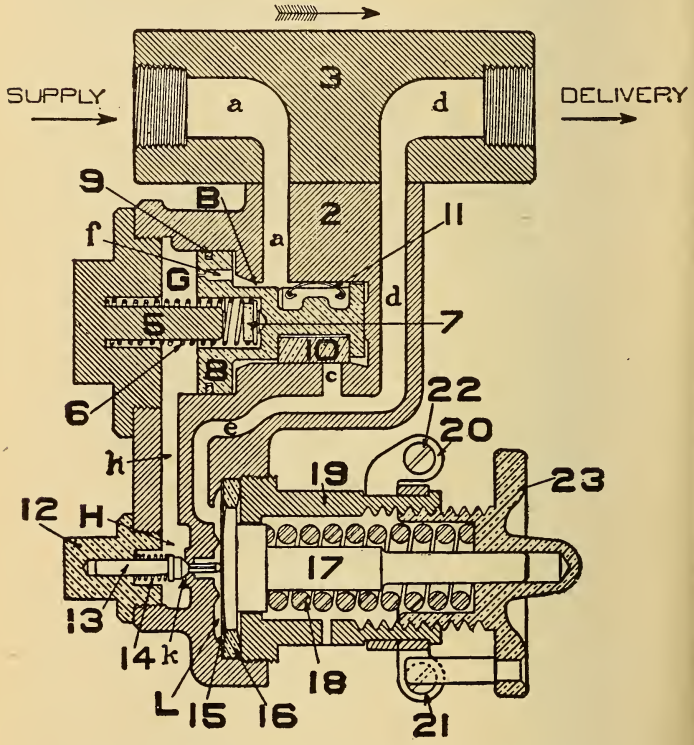


FIG. 318. DIAGRAM OF FEED VALVE, CLOSED

any further flow of air from chamber G. As the air which continues to flow through port *f* will quickly equalize the pressure on both sides of piston 8, spring 6 will

force the piston to the right, moving supply valve 10 and closing port *c*, thereby cutting off communication between the supply and the feed-valve pipe.

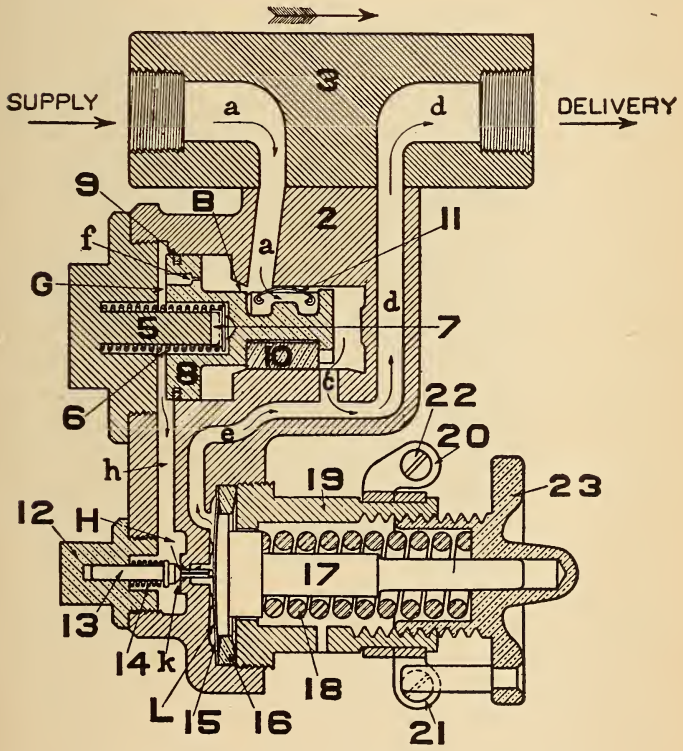


FIG. 319. DIAGRAM OF FEED VALVE, OPEN

When the pressure in the feed-valve pipe falls below that for which the valve is adjusted, regulating spring 18 will force the diaphragm forward, unseat regulating valve

13, and permit the accumulated air pressure in chamber G to escape through port *h,* chamber H, and port *k* to chamber L. This allows main-reservoir pressure in chamber B to force the supply valve piston 8 to left, and open port *c,* which again permits air to pass to the feed-valve pipe until its pressure has been restored to the proper amount. Since this feed valve has a duplex adjusting arrangement, it eliminates the necessity of the two feed valves in high, and low pressure service, as the turning of handle 23 until its pin strikes stops 20, or 21 changes the regulation from one predetermined brake-pipe pressure to another.

To adjust this valve, slacken screw 22, which allows stops 20 and 21 to turn around spring box 19. Adjusting handle 23 should be turned until the valve closes at the lower brake pipe pressure desired, when stop 21 should be brought in contact with the handle pin, at which point it should be securely fastened by tightening screw 22. Adjusting handle 23 should then be turned until the higher adjustment is obtained, when stop 20 is brought in contact with the handle pin and securely fastened.

The names of the parts shown in the diagram, Figs. 318 and 319, are as follows: 2, Valve Body; 3, Pipe Bracket; 5, Cap Nut; 6, Piston Spring; 7, Piston-Spring Tip; 8, Supply-Valve Piston; 9, Piston Packing Ring; 10, Supply Valve; 11, Supply-Valve Spring; 12, Regulating-Valve Cap; 13, Regulating Valve; 14, Regulating-Valve Spring; 15, Diaphragm; 16, Diaphragm Ring; 17, Diaphragm Spindle; 18, Regulating Spring; 19, Spring Box; 20, Upper Stop; 21, Lower Stop; 22, Stop Screw; 23, Adjusting Handle.

REDUCING VALVE.

Fig. 320 is a photograph of the exterior of this valve connected to its pipe bracket, the construction and opera-

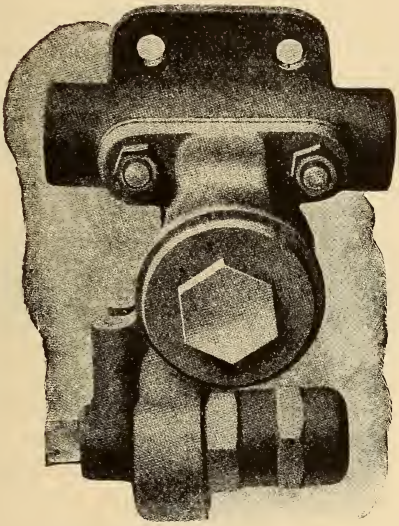


FIG. 320. REDUCING VALVE

tion of which is the same as the feed valve just described, with the exception of the adjusting feature, this valve being designed for single adjustment only.

THE PUMP GOVERNOR.

Fig. 321 shows a sectional view of this governor in its normal position. By reference to the piping diagram in Fig. 295 it will be noted that the connection B leads to the boiler; P to the air pump; MR to the main reservoir;

ABV to the automatic brake valve; FVP to the feed-valve pipe; W is the waste-pipe connection. Steam enters at B and passes by steam valve 26 to the connection P and to the pump. Air from the main reservoir flows

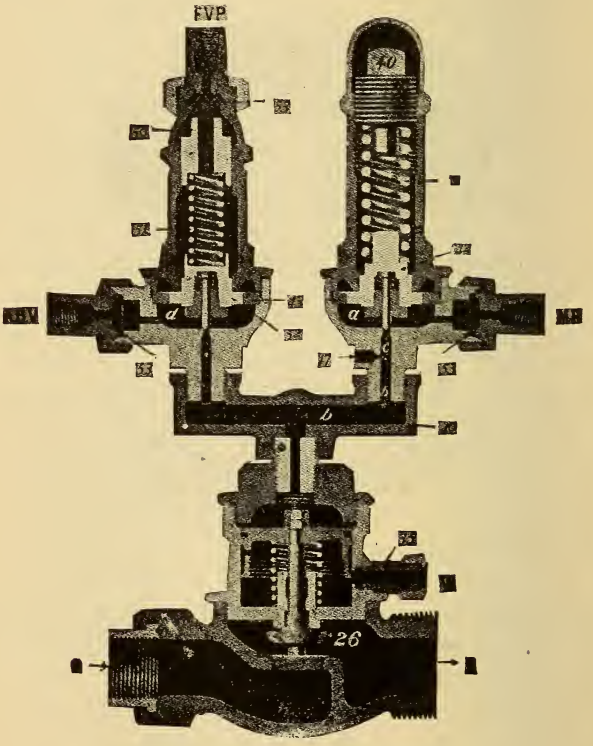


FIG. 321. PUMP GOVERNOR

through the automatic brake valve to the connection marked ABV into chamber *d* below diaphragm 52. Air from the feed-valve pipe enters at the connection FVP and passes to the chamber above the diaphragm, adding

to the pressure of regulating spring 51 in holding it down. As this spring is adjusted to a compression of about 20 pounds, the diaphragm will be held down until the main reservoir-pressure in chamber *d* exceeds the feed-valve pipe pressure by this amount. At such time, diaphragm 52 will raise, unseating its pin valve, and allow air to flow through port *b* to the chamber above the governor piston, forcing it downward, compressing its spring and seating steam valve 26. When main-reservoir pressure in chamber *d* is reduced, the combined spring and air pressures above the diaphragm force it down, seating its pin valve. The pressure in port *b,* and the chamber above the governor piston, which is always able to escape a little from the vent port *c,* will then escape to the atmosphere and allow the piston spring, and steam pressure below valve 26, to raise it, and the governor piston to the position shown. The connection from the main reservoir to chamber *d* is open only when the automatic brake-valve handle is in release, running or holding positions; in the other positions it is closed, at which times this governor head is cut out of action. The connection marked MR in the maximum pressure head is always in communication with the main reservoir, so that when the excess pressure head is cut out by the brake valve, this head controls the pump. When main-reservoir pressure in chamber *a* exceeds the compression of adjusting spring 41, diaphragm 42 will raise its pin valve and allow air to flow through port *b* to the chamber above the governor piston, controlling the pump as above described.

As each governor head has a vent port *c,* from which air escapes whenever pressure is present in port *b,* to avoid an unnecessary waste of air, one of these should be plugged.

To adjust this governor, remove the cap nut and turn adjusting nut 50 until the compression of spring 51 is equal to the excess of pressure desired.

QUESTIONS

949. In what respect does the new ET. Locomotive brake equipment differ materially from the standard automatic and straight air brake?

950. Can the ET. equipment be applied to any locomotive; no matter what kind of service?

951. Mention one of the principal advantages in connection with the design of the valves.

952. What are the three important advantages connected with its operation?

953. What can be said regarding the manipulation of the ET. brake, and the automatic and straight air brake?

954. In what position should the handle be, when not in use?

955. When it is desired to apply the locomotive and train brakes, how must the automatic brake valve handle be moved?

956. Describe the method of releasing the train brakes.

957. Describe the method of making an emergency application.

958. In order to make a smooth and accurate, two application passenger stop, what should be done?

959. Describe the proper method of making and releasing an independent application.

960. How should the independent brake be operated, when handling long trains on the road, or in switching service?

961. How ma the engine brakes only be released, and still leave the train brakes applied?

962. What should be done with the train brakes before detaching the engine?

963. Should the automatic brakes be used to hold a train, or engine standing on a grade, for any length of time?

964. What is the safest way to hold a train standing on a grade?

965. Describe the proper method of stopping a descending train, and then holding it with the independent brake.

966. In what position should the independent brake valve handle be left when the engine is standing at a coal chute or water plug?

967. In what position should the handle of the automatic brake valve be placed in case of an accidental application—such as a bursted hose, or break in two of train?

968. In case there are two or more engines in a train, what should be done with the air equipment of each one, except the one from which the brakes are being handled?

969. What should be done with the brake equipment on the engine, before leaving the roundhouse?

970. Name the various parts of the equipment, and the purpose of each.

971. Name the different parts of the piping appertaining to the ET equipment.

972. What are the functions of the main reservoir cut-out cock?

973. In what two ways does the automatic brake valve receive air from the main reservoir?

974. How many connections has the distributing valve?

975. What are the functions of the first three of these connections?

976. For what purpose are the other two?

977. What is the important feature of the ET brake equipment?

978. Describe briefly what takes place within the distributing valve during an independent application.

979. What causes independent lap?

980. Between what two pressures does the application piston of the distributing valve vibrate?

981. How is the pressure maintained in the brake cylinders during an application?

982. How is independent release accomplished?

983. How may independent lap be again resumed?

984. What parts are brought into action during automatic operation?

985. Describe in general terms what occurs within the distributing valve during a service application of the automatic brake.

986. Upon what does the amount of pressure in the application chamber of the distributing valve depend?

987. What causes the position known as service lap?

988. Does the pressure maintaining feature also apply to automatic application?

989. Are the engine brakes released when the automatic brake valve is placed in release position?

990. What, then, must be done in order to release the engine brakes?

991. What takes place within the distributing valve during an emergency application?

ing to chamber D; *r* is the warning port leading to the exhaust; *p* is the port leading to the pump governor; *l* leads to the application-chamber pipe; *n* leads to the double-heading pipe.

In describing the operation of the brake valve, it will be more readily understood if the positions are taken up in the order in which they are most generally used, rather than their regular order as mentioned above.

Running Position. This is the proper position of the handle to release the engine and tender brakes; also when the brakes are not being used, and the system is charged and ready for an application. In this position, cavity *f* in the rotary valve connects ports *b* and *d* in the valve seat, affording a large direct passage from the feed valve to the brake pipe, so that the latter will charge up as rapidly as the feed valve can supply the air, but cannot attain a pressure above that for which the feed valve is adjusted. Cavity *k* in the rotary valve connects ports *c* and *g* in the valve seat, so that chamber D, and the equalizing reservoir charge uniformly with the brake pipe, keeping the pressures on the two sides of the equalizing piston equal. Port *s* in the rotary valve registers with port *p* in the valve seat, permitting main-reservoir pressure, which is present at all times above the rotary valve, to pass to the excess-pressure head of the pump governor. Port *h* in the rotary valve registers with port *l* in the seat connecting the application chamber pipe to the exhaust cavity EX.

Service Position. This position gives a gradual reduction of brake-pipe pressure to cause a service application. Port *h* in the rotary valve registers with port *s* in the valve seat, allowing air from chamber D and the

equalizing reservoir to escape to the atmosphere through cavities *o* in the rotary valve and EX in the valve seat. Port *e* is restricted so as to make the pressure in the equalizing reservoir, and chamber D fall gradually. As all other ports are closed, the fall of pressure in chamber D allows the brake-pipe pressure under the equalizing piston to raise it, and unseat the discharge valve, allowing brake-pipe air to flow to the atmosphere. When the pressure in chamber D is reduced the desired amount, the handle is moved to the *lap position,* thus stopping any further reduction in that chamber. Air will continue to discharge from the brake-pipe until its pressure has fallen to an amount a trifle less than that retained in chamber D, permitting the pressure in this chamber to force the piston downward and stop the discharge of brake-pipe air. It will be seen, therefore, that the amount of reduction in the equalizing reservoir determines that in the brake pipe, regardless of the length of the train.

LAP POSITION. This position is used while holding the brakes applied after a service application until it is desired either to make a further brake-pipe reduction, or to release them; also to prevent loss of main-reservoir pressure of the release of the brake in the event of a burst hose, a break-in-two, or the opening of the conductor's valve. Lap position is also used on all engines in a train that are not controlling the train brakes, as, with the handle in this position, port *h* in the rotary valve connects with port *u* in the seat. Therefore, when the double cut-out cock is turned to the position which cuts out the brake pipe, it makes a direct opening from port *i* in the distributing valve through the double-heading pipe to the atmosphere, and is the passage through which the air escapes from the application chamber when the automatic brakes are being released.

RELEASE POSITION. The purpose of this position is to provide a large and direct passage from the main reservoir to the brake pipe, to permit a rapid flow of air into the latter, to insure a quick release and recharging of the train brakes, but without releasing the engine and tender brakes.

Air at main-reservoir pressure flows through port *a* in the rotary valve to port *b* in the valve seat and to the brake pipe. At the same time, port *j* in the rotary valve registers with the equalizing port *g* in the valve seat, permitting main-reservoir pressure to enter chamber D above the equalizing piston.

In this position, port *s* in the rotary valve registers with warning port *r* in the seat and allows a small quantity of air to escape into the exhaust cavity EX, which makes sufficient noise to attract the engineer's attention to the position in which the valve handle is standing. If the handle is allowed to remain in this position, the brake system would be charged to main-reservoir pressure. To avoid this, the handle must be moved to Running or Holding Positions. The small groove in the face of the rotary valve which connects with port *s*, extends to port *p* in the valve seat, allowing main-reservoir pressure to flow to the excess-pressure head of the pump governor.

HOLDING POSITION. This position is so named because the locomotive brakes are held applied, as they are in release position, while the train brakes feed up to the feed-valve pressure. All ports register as in running position, except port *l*, which is closed.

Therefore, the only difference between Running and Holding Positions is, that in the former the application chamber is open to the atmosphere, while in the latter it is not.

EMERGENCY POSITION. This position is used when the most prompt and heavy application of the brakes is desired. Port *x* in the rotary valve registers with port *c* in the valve seat, making a large and direct communication between the brake pipe and atmosphere through cavity *o* in the rotary valve and EX in the valve seat. This direct passage causes a sudden and heavy discharge of brake-pipe pressure, causing the triple valves and distributing valve to go to the emergency position and apply the brake in the shortest possible time.

In this position the groove *n* in the rotary valve connects ports *g* and *l* in the valve seat, thereby allowing equalizing reservoir air to flow into the application chamber.

The oil plug 29 is placed in the top case 4, at a point to fix the level of the oil surrounding the rotary valve. Leather washer 8 prevents air in the rotary valve chamber from leaking past the rotary valve key to the atmosphere. Spring 30 keeps the rotary valve key firmly pressed against washer 8 when no main-reservoir pressure is present. The handle 9 contains a latch 11, which fits into notches in the top case, so located as to indicate the different positions of the brake valve handle. The spring 10 back of the latch forces the latter against the body with sufficient pressure to distinctly indicate when the handle arrives at each position.

To remove the brake valve take off nuts 27, thus allowing it to come away without disturbing the pipe bracket, or breaking any pipe joints. To take the valve proper apart, remove cap screws 28.

The brake valve should be located so that the engineer can operate it from his usual position, while looking forward or back out of the side-cab window, and in such

a manner that the handle will not meet with any obstruction throughout its entire movement.

The oil around the rotary valve furnishes thorough lubrication. Valve oil should be used for this purpose.

Fig. 313 shows all the principal parts, the proper names of each being as follows: 2, Bottom Case; 3, Rotary-Valve Seat; 4, Top Case; 5, Pipe Bracket; 6, Rotary Valve; 7, Rotary-Valve Key; 8, Key Washer; 9, Handle; 10, Handle-Latch Spring; 11, Handle Latch; 12, Handle-Latch Screw; 13, Handle Nut; 14, Handle Lock Nut; 15, Equalizing Piston; 16, Equalizing-Piston Packing Ring; 17, Valve-Seat Upper Gasket; 18, Valve-Seat Lower Gasket; 19, Pipe-Bracket Gasket; 20, Small Union Nut; 21, Brake-Valve Tee; 22, Small Union Swivel; 23, Large Union Nut; 24, Large Union Swivel; 25, Bracket Stud; 26, Bracket-Stud Nut; 27, Bolt and Nut; 28, Cap Screw; 29, Oil Plug; 30, Rotary-Valve Spring.

THE INDEPENDENT BRAKE VALVE.

Fig. 314 illustrates this valve, which is of the rotary type. Fig. 315 shows a vertical section through the center of the valve, and a horizontal section through the valve body, with the rotary valve removed, showing the rotary valve seat. Fig. 316 shows this valve similarly to Fig. 315, with the addition of a top view of the rotary valve. In these views, the pipe connections and positions of the handle are indicated. Port *b* in the seat leads to the supply connection from the main reservoir through the Reducing Valve. Port *c* leads to that portion of the application-chamber pipe which connects to the automatic-brake valve. Port *d* leads to that portion of the application-chamber pipe which connects the dis-

tributing valve. Port *h*, in the center, is the exhaust port leading directly to the atmosphere. Exhaust cavity *g* in the rotary valve is always in communication with exhaust port *h*. Groove *e* in the face of the valve communicates at one end with a port through the valve. This groove is always in communication with supply port *b*, and through the opening just mentioned air is admitted

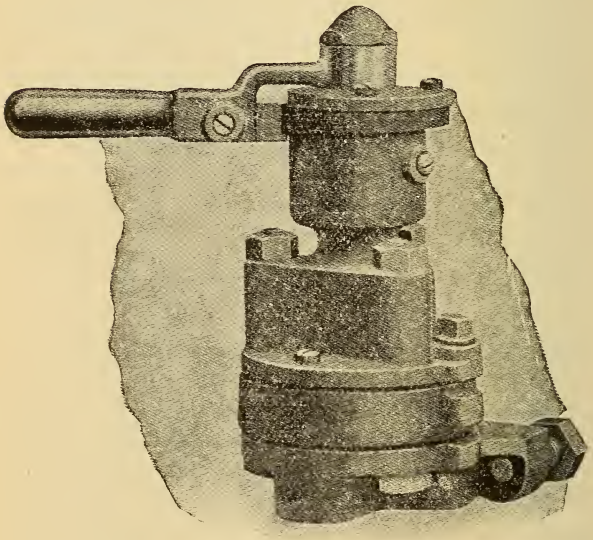


FIG. 314. THE INDEPENDENT BRAKE VALVE

to the chamber above the rotary valve, thus keeping it to its seat. Port *f* in the rotary valve consists of two circular openings in the face joined by a cylindrical passage over the top of cavity *g*.

RUNNING POSITION. This is the position that the independent brake valve should be carried in at all times

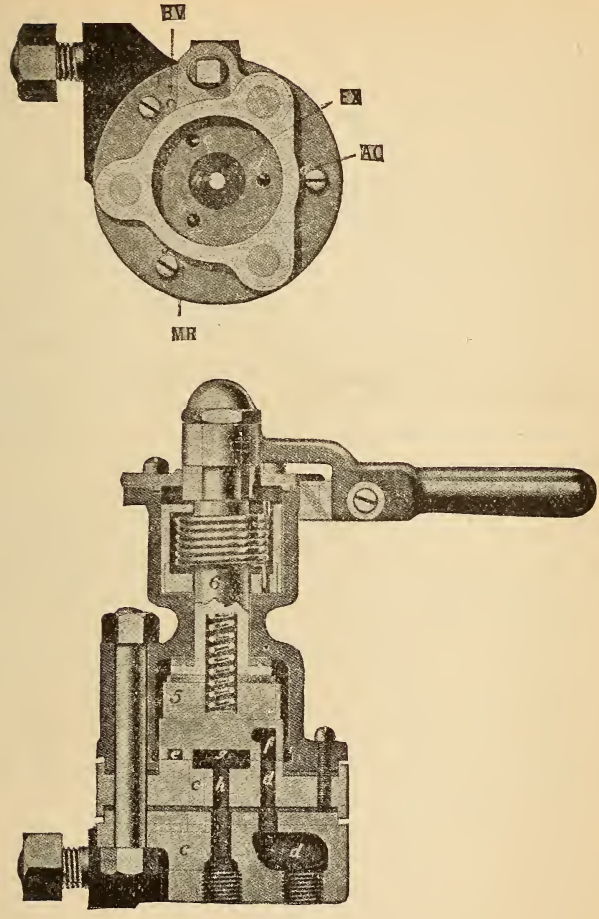


FIG. 315. INTERIOR VIEW OF THE INDEPENDENT BRAKE VALVE

CONNECTIONS:

BV—Application-Chamber Pipe to Automatic Brake Valve; EX—Exhaust; AC—Application-Chamber Pipe to Distributing Valve; MR—Reducing-Valve Pipe

when the independent brake is not in use. Port *f* in the rotary valve connects ports *c* and *d* in the valve seat, thus establishing communication between the application chamber of the distributing valve and port *l* of the automatic brake valve. Therefore, it will be seen that if the automatic brake valve is in running position, and the independent brakes applied, they can be released by returning the independent valve to running position.

Service Position. To apply the independent brakes, move the brake valve to the application position; groove *e* connects ports *b* and *d*, allowing air to flow to the application chamber of the distributing valve. Since the supply pressure to this valve is fixed by the regulation of the reducing valve to 45 pounds, this is the maximum cylinder pressure that can be obtained.

Lap Position. This position is used to hold the independent brakes applied after the desired cylinder pressure is obtained, at which time all communication between operating ports is closed.

Release Position. This position is used to release the pressure from the application chamber when the automatic brake valve is not in running position. In this position, the offset in cavity *g* registers with port *d*, allowing pressure in the application chamber to flow through ports *d*, *g* and *h* to the atmosphere.

In order to prevent leaving the handle in the release position, and thereby make it impossible to operate the locomotive brakes by the automatic brake valve, spring 9 automatically returns handle 15 from the release to the running position.

The purpose of the oil plug 20 is the same as that described in the automatic brake valve.

The location of this valve should be governed by the

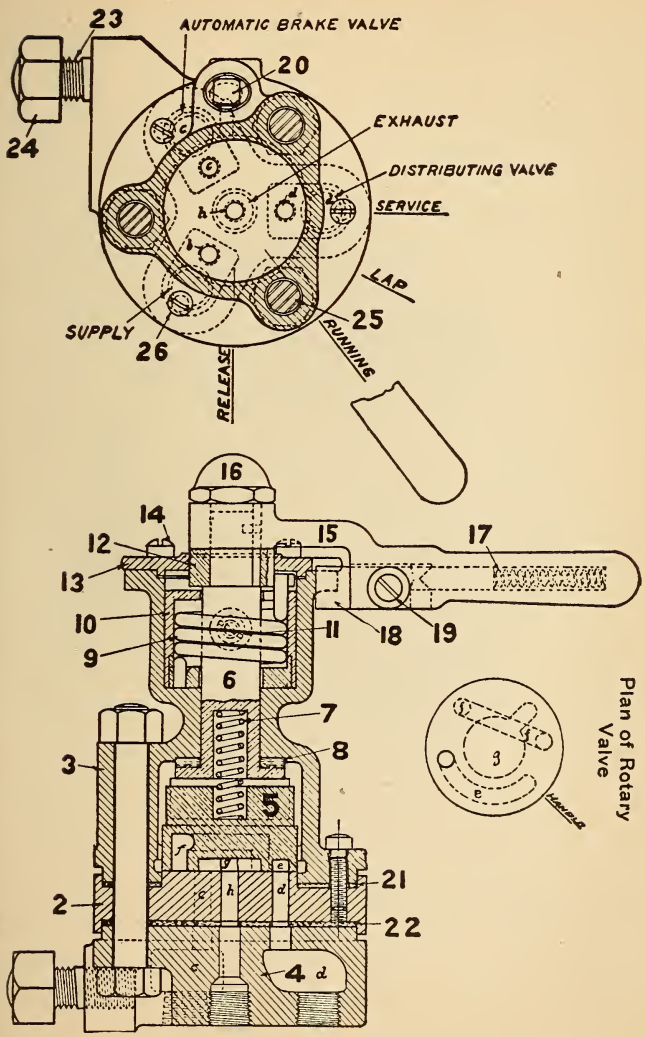


FIG. 316. INTERIOR VIEWS OF THE INDEPENDENT BRAKE VALVE

same considerations as those mentioned concerning the automatic brake valve. The names of its parts are as follows, referring to Fig. 316.

2, Rotary-Valve Seat; 3, Valve Body; 4, Pipe Bracket; 5, Rotary Valve; 6, Rotary-Valve Key; 7, Rotary-Valve Spring; 8, Key Washer; 9, Return-Spring; 10, Return-Spring Casing; 11, Casing Screw; 12, Return-Spring Clutch; 13, Cover; 14, Cover Screw; 15, Handle; 16, Handle Nut; 17, Latch Spring; 18, Latch; 19, Latch Screw; 20, Oil Plug; 21, Upper Gasket; 22, Lower Gasket; 23, Bracket Stud; 24, Bracket-Stud Nut; 25, Bolt and Nut; 26, Cap and Screw.

THE FEED VALVE.

This valve, Fig. 317, is a slide-valve feed valve of an improved type, and with this equipment is connected to a pipe bracket located in the piping between the main reservoir and the automatic brake valve, receiving its supply of air from the main-reservoir pipe, and delivering it into the feed-valve pipe. It is for the purpose of controlling brake-pipe pressure when the automatic brake valve handle is in running or holding positions.

Figs. 318 and 319 are diagrammatic views of the valve and pipe bracket having the ports and operating parts in one plane to facilitate description. It consists of two sets of parts, the supply and regulating. The supply parts, which control the flow of air through the valve, consist of the supply valve 10, and its spring 11; the supply-valve piston 8 and its spring 6. The regulating parts consist of the regulating valve 13, regulating-valve spring 14, diaphragm 15, diaphragm spindle 17, regulating handle 23. Main-reservoir air enters through port

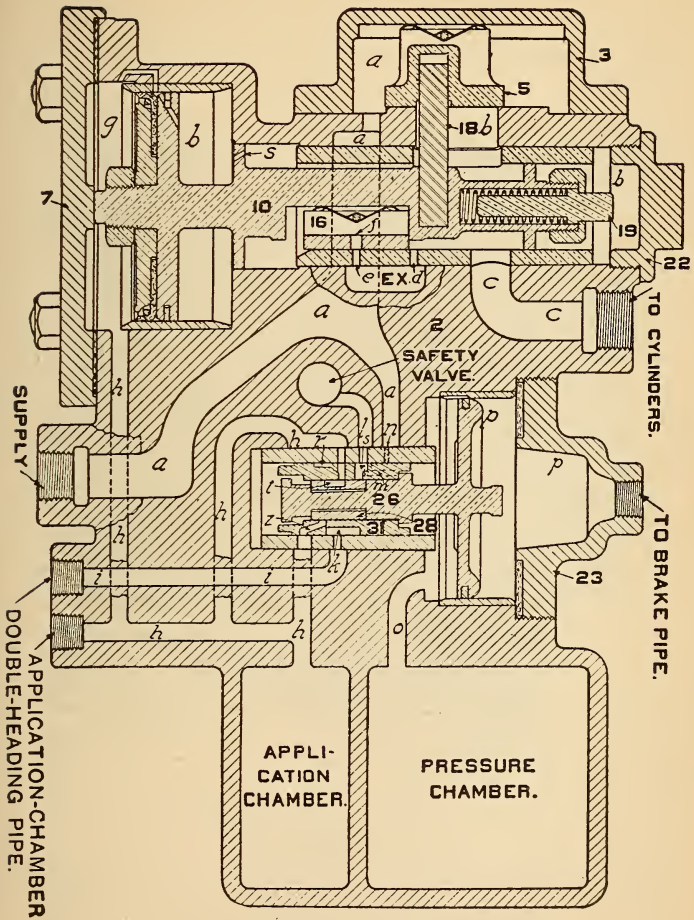
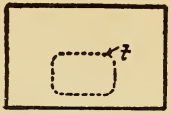
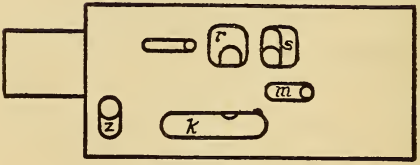


FIG. 306. RELEASE POSITION

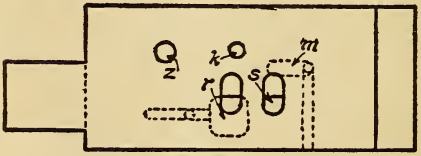
When Locomotive Brake is released by Independent Brake Valve after an application by Brake Pipe Reduction



PLAN OF
GRADUATING VALVE.



FACE OF SLIDE VALVE.



PLAN OF SLIDE VALVE

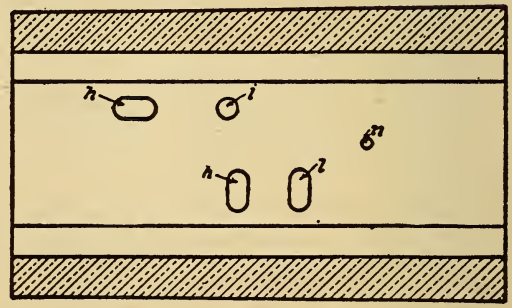


FIG. 307. GRADUATING VALVE, EQUALIZING SLIDE VALVE, AND SLIDE VALVE SEAT

exception of the release, which is brought about by the equalizing piston 26 moving to the release position and causing exhaust cavity in the equalizing slide valve 31

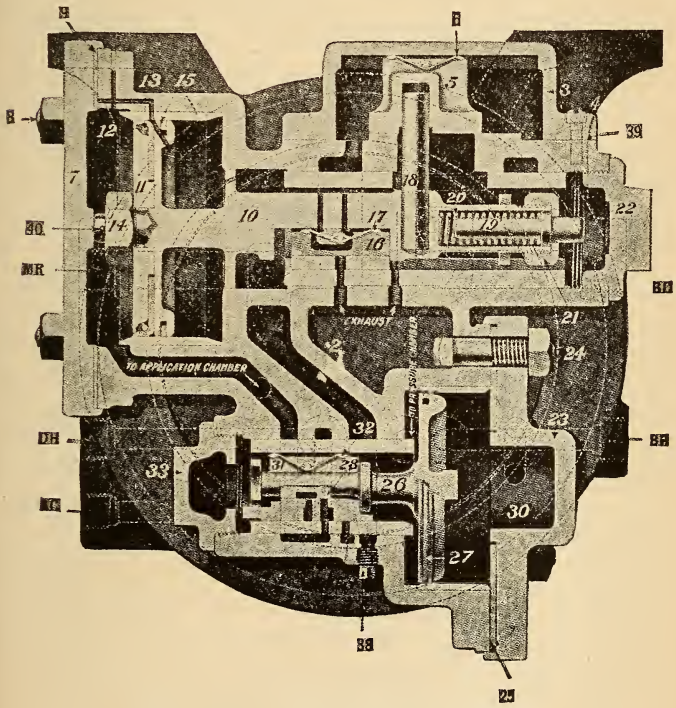


FIG. 308. DISTRIBUTING VALVE CONNECTIONS:
MR—Main Reservoir Pipe; DH—Double-Heading Pipe; AC—Application-Chamber Pipe; BC—Brake-Cylinder Pipe; BP—Brake Pipe

to connect ports *i* and *h* in the slide valve seat, thereby permitting the pressure in the application chamber to escape to the atmosphere through the double heading

pipe, the double cut-out cock, and the automatic brake valve. In double heading, therefore, the release of the distributing valve is similar to that of a triple valve.

To remove piston 10 and slide valve 16, it is absolutely necessary to *first* remove cover 3, slide valve 5 and valve pin 18.

Referring to Figs 298 and 308, the proper names of parts of this apparatus are as follows: 2, Body; 3, Application-Valve Cover; 4, Cover Screw; 5, Application Valve; 6, Application-Valve Spring; 7, Application-Cylinder Cover; 8, Cylinder-Cover Bolt and Nut; 9, Cylinder-Cover Gasket; 10, Application Piston; 11, Piston Follower; 12, Packing-Leather Expander; 13, Packing Leather; 14, Application-Piston Nut; 15, Application-Piston Packing Ring; 16, Exhaust Valve; 17, Exhaust-Valve Spring; 18, Application-Valve Pin; 19, Graduating Stem; 20, Graduating Spring; 21, Graduating-Stem Nut; 22, Upper Cap Nut; 23, Equalizing Cylinder Cap; 24, Cylinder Cap Bolt and Nut; 25, Cylinder-Cap Gasket; 26, Equalizing Piston; 27, Equalizing-Piston Packing Ring; 28, Graduating Valve; 29, Graduating-Valve Spring; 31, Equalizing Slide Valve; 32, Equalizing-Slide-Valve Spring; 33, Lower Cap Nut; 34, Safety Valve; 35, Double-Chamber Reservoir; 36, Reservoir Stud and Nut; 37, Reservoir Drain Plug; 38, Distributing-Valve Drain Plug; 39, Application-Valve-Cover Gasket; 40, Application Piston Cotter; 41, Distributing-Valve Gasket.

Fig. 309 is a sectional view of the safety valve which is a necessary part of the distributing valve. It is of an improved type, which insures reliability of operation. It is unlike the ordinary safety valve, as its construction is such as to cause it to close quickly with a "pop" action,

insuring its seating firmly. It is very sensitive in operation, and responds to very slight differences of pressure.

The names of the parts are: 2, Body; 3, Cap Nut; 4, Valve; 5, Stem Valve; 6, Adjusting Spring; 7, Adjusting Nut.

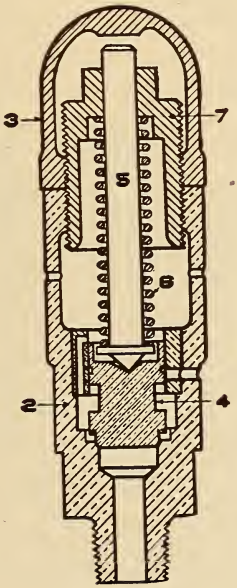


FIG. 309. SAFETY VALVE

Valve 4 is held to its seat by the compression of the spring 6 between the stem and adjusting nut 7. When the pressure below valve 4 is in excess of the force exerted by the spring, it raises, being guided in its movement by the brass bush in the body 2. Ports are drilled in this bush; one outward through the body to the atmosphere, and the other upward to the spring chamber.

Although only one of each of these is shown in the cut, there are eight of the first and two of the second. As the valve moves upward, its lift is determined by the stem 5 striking the cup nut 3. It closes the vertical ports connecting the valve and spring chambers and opens the lower ports to the atmosphere. As the air pressure below valve 4 decreases, and the tension of the spring forces the stem and valve downward, the valve gradually closes the lower ports to the atmosphere, and opens those between the valve and spring chambers. The discharge air pressure then has access to the spring chamber. This chamber is always connected to the atmosphere by two small holes through the body 2; the air from the valve chamber enters more rapidly than it can escape through these holes, causing pressure to accumulate above the valve, and close it with the "pop" action before mentioned.

The adjustment of this safety valve is accomplished by removing cap nut 3, and screwing up or down on adjusting nut 7. After the proper adjustment is made, cap nut 3 must be replaced and securely tightened, and the valve operated a few times. Particular attention must be given to the holes in the valve body to see that they are open, and that they are of the proper size, especially the two upper holes.

This safety valve should be adjusted for 53 pounds.

THE TYPE H AUTOMATIC BRAKE VALVE.

This Brake Valve, although modeled to a considerable extent upon the principles of previous valves, is necessarily different in detail, since it not only performs all the functions of such types, but also those absolutely

necessary to obtain all the desirable operating features of the Distributing Valve.

Fig. 310 is taken from a photograph of this brake valve, while Fig. 311 shows two views, the upper one being a plan view with section through the rotary-valve chamber, the rotary valve being removed; the lower one a vertical section. In these views the pipe connections are indicated.

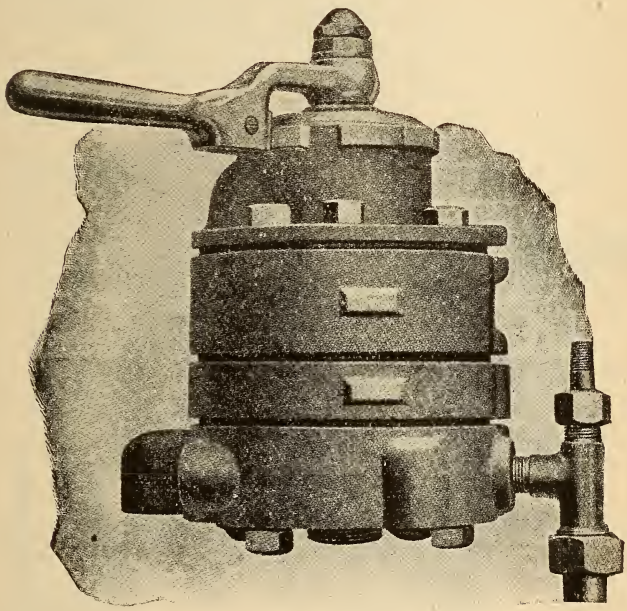
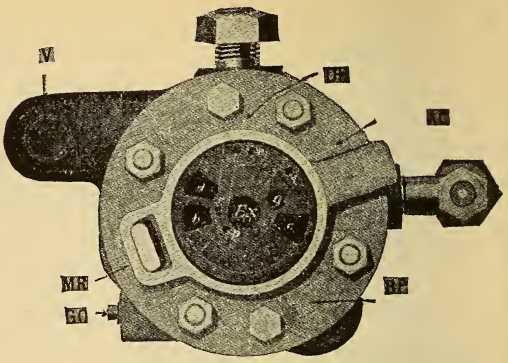


FIG. 310. TYPE H BRAKE VALVE

Fig. 312 is a top view, showing the six positions of the brake-valve handle, which are, beginning at the extreme left, Release, Running, Holding, Lap, Service and Emergency.



ROTARY-VALVE SEAT.

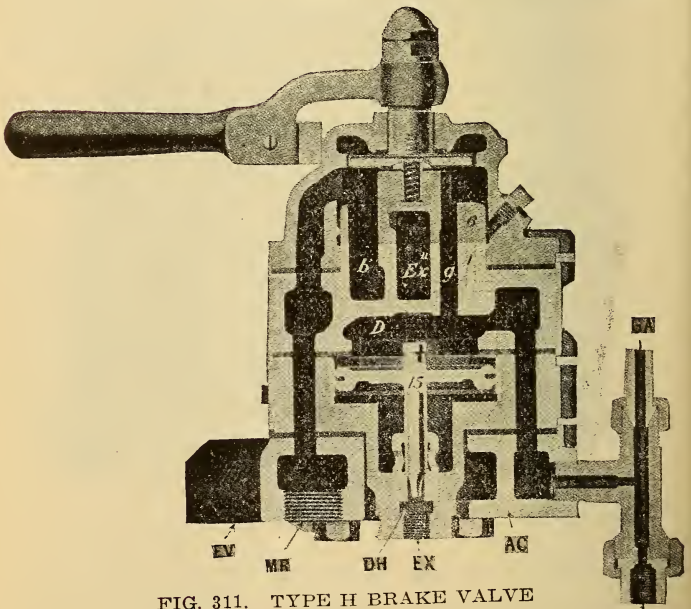


FIG. 311. TYPE H BRAKE VALVE

CONNECTIONS:

FV—Feed-Valve Pipe; MR—Main-Reservoir Pipe; GO—To Governor; DH—Double Heading Pipe; EX—Exhaust; AC—Application-Chamber Pipe; BP—Brake Pipe; GA—Duplex Air Gauge; ER—Equalizing Reservoir

Fig. 313 shows two views of this valve similar to those of Fig. 311, with the addition of a plan or top view of the rotary valve. Referring to the latter, *a*, *j* and *s* are ports extending directly through it, the latter connecting with a groove in the face; *f* and *k* are cavities in the valve

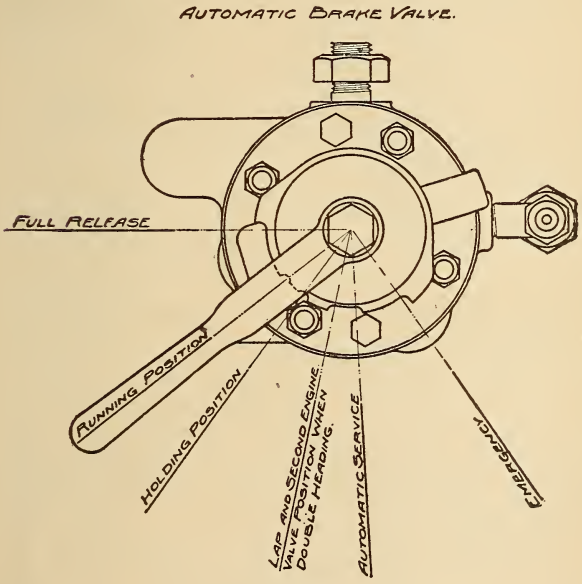


FIG. 312

face; *o* is the exhaust cavity; *x* is a port in the face of the valve connecting with *o*; *h* is a port in the face which passes over cavity *k* and connects with exhaust cavity *o*; *n* is a groove in the face. Referring to the ports in the rotary-valve seat, *d* leads to the feed-valve pipe; *b* and *c* lead to the brake pipe; *g* leads to chamber D; EX is the exhaust opening; *e* is the preliminary exhaust port lead-

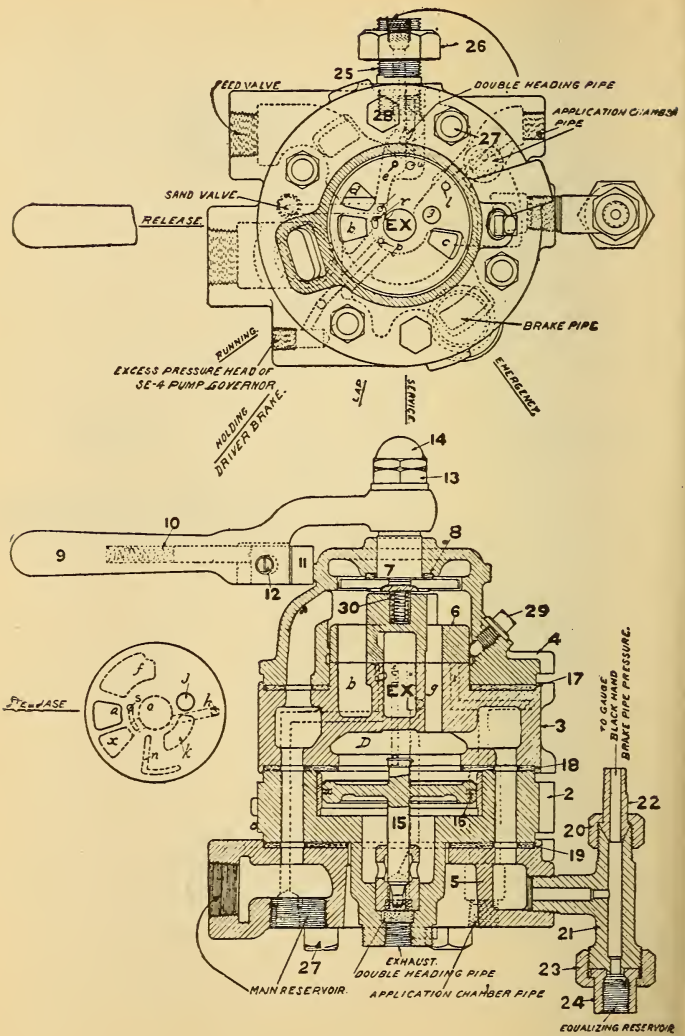


FIG. 313. AUTOMATIC BRAKE VALVE

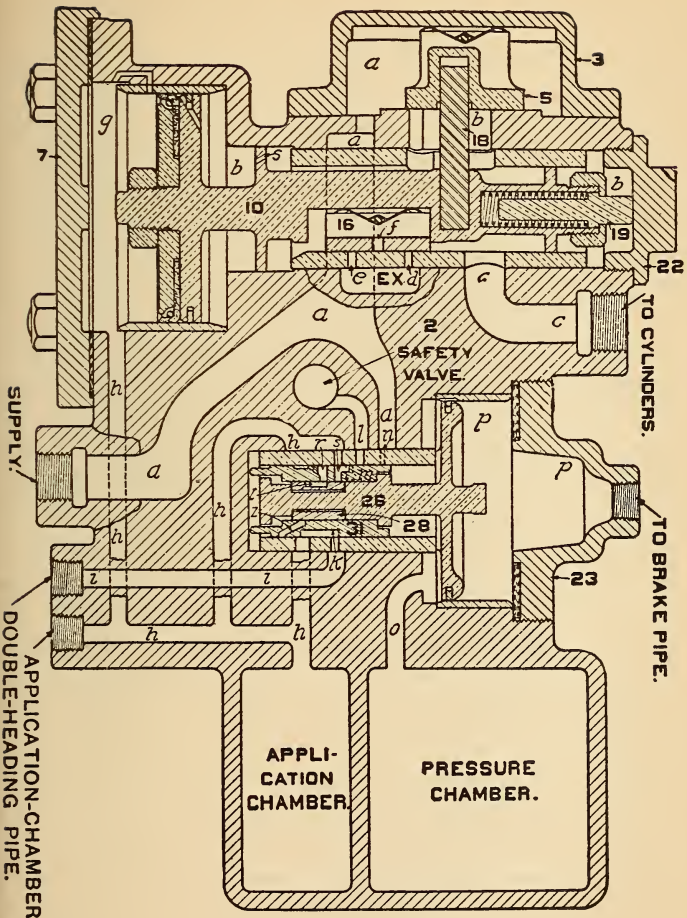


FIG. 301. INDEPENDENT LAP

causing exhaust valve 16 to open exhaust ports *e* and *d* as shown in Fig. 299, thereby allowing brake-cylinder pressure to escape to the atmosphere.

If the independent brake valve is returned to lap before all of the application-chamber pressure has escaped, the application piston 10 will return to independent lap position as soon as the brake-cylinder pressure is reduced a little below that remaining in the application chamber.

AUTOMATIC OPERATION.

During automatic operation of the brakes, the lower movable parts, known as the equalizing parts, are brought into action.

AUTOMATIC RELEASE. Referring to Fig. 299, which shows the movable parts of the valve in the release position, it will be seen that as chamber *p* is connected to the brake pipe, brake-pipe air flows through the feed groove around the top of piston 26 into the chamber above the slide valve 31, and through port *o* to the *pressure chamber,* until the pressures on both sides of the piston are equal.

SERVICE. When a service application is made with the automatic brake valve, the brake-pipe pressure in chamber *p* is reduced, causing a difference in pressure on the two sides of this piston, which results in the piston moving toward the right. The first movement of the piston closes the feed groove, and at the same time moves the graduating valve until it uncovers the upper end of port *z* in the equalizing slide valve 31. As the piston continues its movement, the shoulder on the end of its stem engages the slide valve, which is then also moved to the right until port *z* in the slide valve registers with port

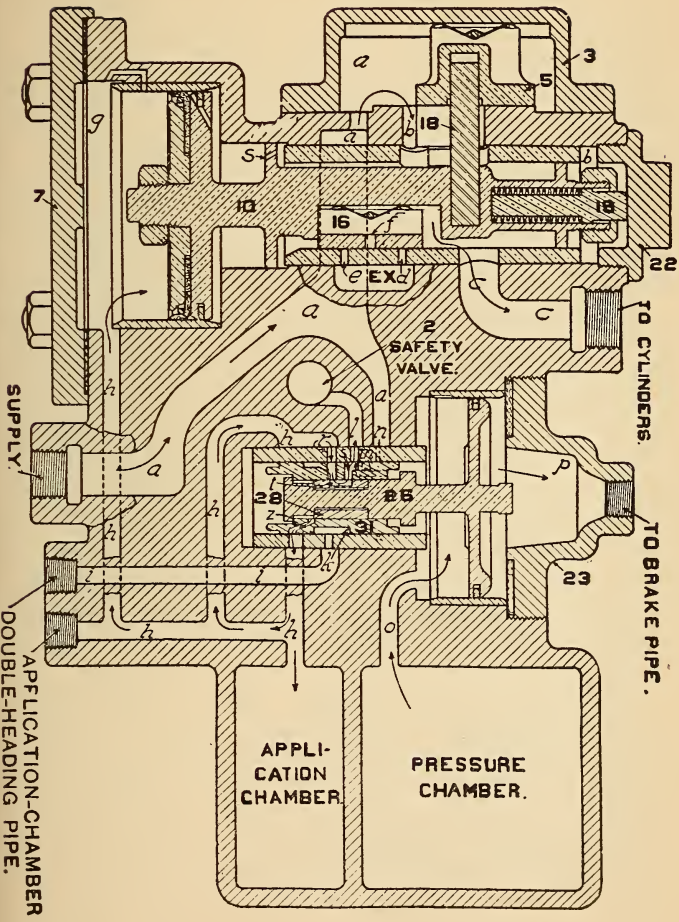


FIG. 302. AUTOMATIC SERVICE

h in the seat. As the slide valve chamber is always in communication with the pressure chamber, air can now flow from it to the application chamber. This pressure forces application piston 10 to the right, as shown in Fig. 302, causing application valve 5 to uncover port *b* and allow main reservoir air to flow to the brake cylinders through port *c*, as in an independent application.

During the movement just described, cavity *t* in the graduating valve connects ports *r* and *s* in the equalizing slide valve, and by the same movement ports *r* and *s* are brought into register with ports *h* and *l* in the seat, thus establishing a communication from the application chamber to the safety-valve, which being set at 53 pounds, limits the brake-cylinder pressure to this amount during a full service application.

The amount of pressure resulting in the application chamber for a certain brake-pipe reduction, depends on the comparative volumes of the application and pressure chambers. These volumes are such that with 70 pounds in the pressure chamber and nothing in the application chamber, if they are allowed to remain connected by the ports in the slide valve, they will equalize at about 50 pounds.

Service Lap. The conditions just described continue until the pressure in the *pressure chamber* is reduced enough below that in the brake pipe to cause the difference in pressure on the two sides of piston 26 to force it and graduating valve 28 to the left until the shoulder on the piston stem strikes the right-hand end of slide valve 31, the position indicated in Fig. 303, and known as Service Lap. In this position, graduating valve 28 has closed port *z* so that no more air can flow from the *pressure chamber* to the application chamber;

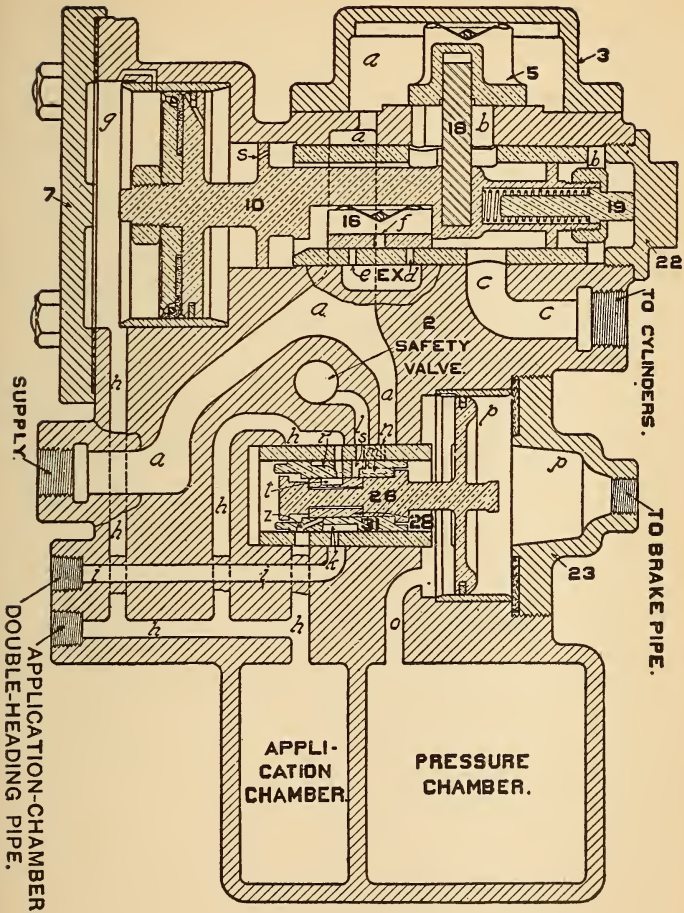


FIG. 303. SERVICE LAP

and it also has closed port *s*, cutting off communication to the safety valve. The flow of air past application valve 5 to the brake cylinders continues until their pressure equals that in the application chamber when the graduating spring forces piston 10 to the position shown in Fig. 303, closing port *b*. The brake-cylinder pressure is then practically the same as that in the *application chamber*.

It will be seen that whatever pressure exists in the *application chamber* will be maintained in the brake cylinder by the "pressure maintaining" feature already described.

When the automatic brake valve is placed in release position, and the brake-pipe pressure in chamber *p* is increased above that in the pressure chamber, equalizing piston 26 moves to the left, carrying with it equalizing slide valve 31 and graduating valve 28 to the release position as shown in Fig. 299. The feed groove now being open permits the pressure in the pressure chamber to equalize with that in the brake pipe as before described. This action does not release the locomotive brakes because it does not discharge application chamber pressure. The double-heading pipe is closed at the double cut-out cock, and the application chamber pipe is closed by the rotary valve of the automatic brake valve. Therefore, to release the locomotive brakes, the automatic brake valve must be moved to running position, or the independent brake valve must be held in release position, in which positions the rotary valve of either will connect the application chamber pipe with the atmosphere. As the application chamber pressure escapes, the cylinder pressure will force application piston 10 to the left until

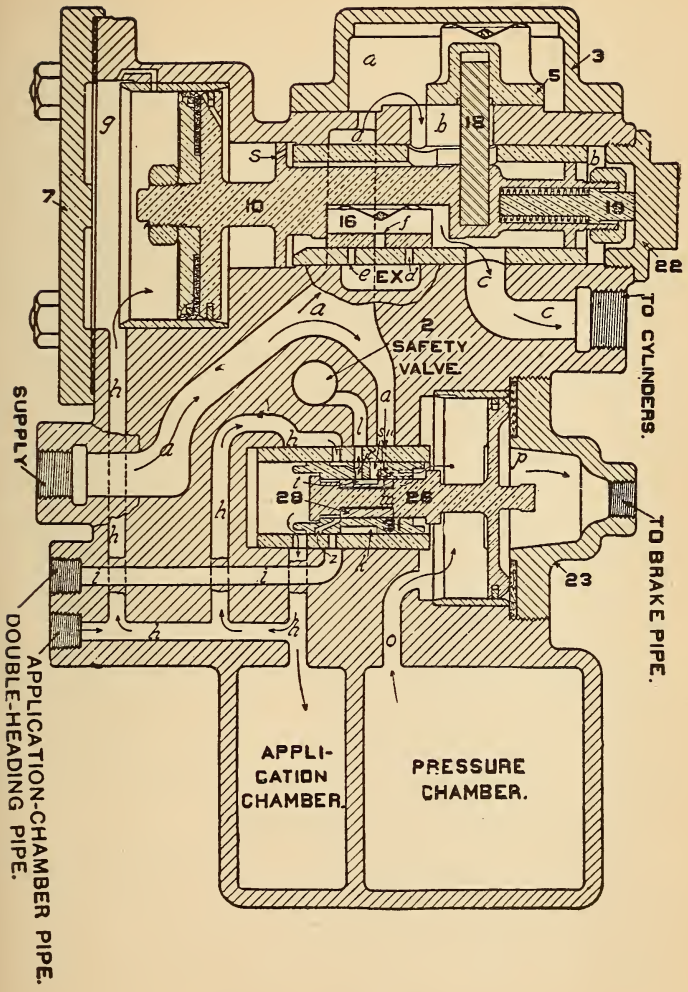


FIG. 304. EMERGENCY

exhaust valve 16 uncovers exhaust ports *d* and *e,* allowing brake-cylinder pressure to escape.

Emergency. When a sudden and heavy brake-pipe reduction is made, as in an emergency application, the pressure in the pressure chamber forces application piston 26 to the right until it strikes against the leather gasket beneath head 23 as shown in Fig. 304. This movement causes slide valve 31 to uncover port *h* in the bush, making a large opening from the *pressure chamber* to the *application chamber,* so that they quickly become equalized. In the emergency position of the automatic brake valve, the volume of the equalizing reservoir is connected to that of the application chamber. This reservoir volume, together with that of the pressure chamber at 70 pounds pressure, equalizes into the application chamber at about 60 pounds. The dotted port *m* in the slide valve registers with port *n* in the seat connecting with supply passage *a,* allowing air from the main reservoir to enter the slide valve and application chambers. A cavity in the slide valve registers with port *h* in the seat. Port *r* in the slide valve registers with port *l* leading to the safety valve. The cavity and port *r* in the slide valve are connected by a small port, the size of which permits the air in the application chambers to escape a little faster than ports *m* and *n* can supply it, preventing the pressure from rising above the amount desired.

In High-Speed Brake Service, the feed valve is regulated for 110 pounds brake-pipe pressure instead of 70, and main-reservoir pressure is 130 or 140 pounds. Under these conditions an emergency application raises the *application chamber* pressure to about 85 pounds, but the area of the small passage to port *r* is so proportioned that the flow of *application-chamber* pressure to the safety

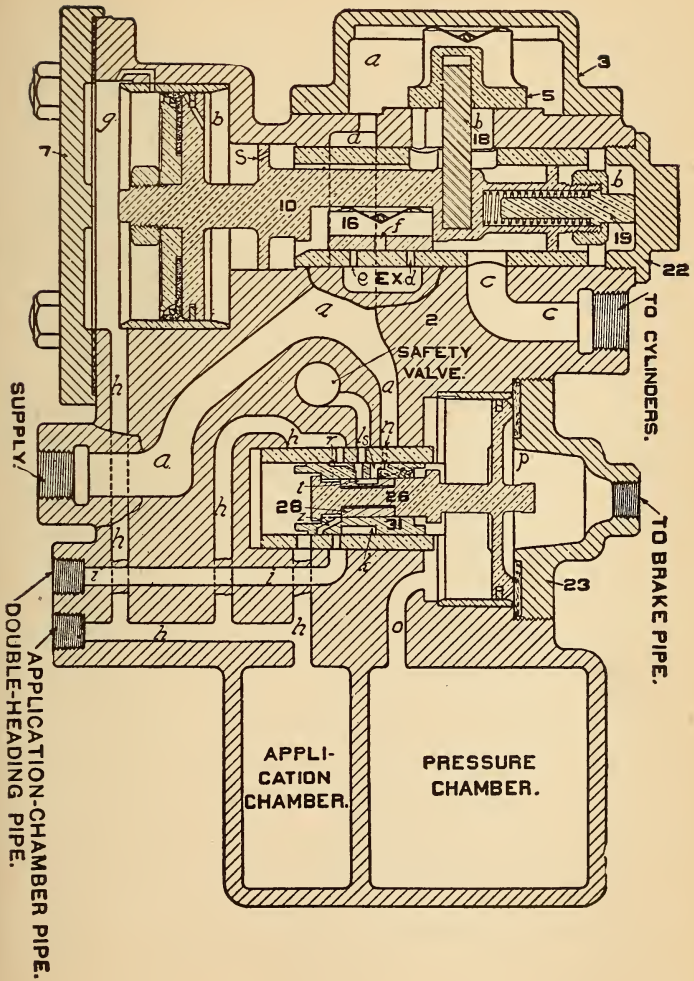


FIG. 305. EMERGENCY LAP

valve is just enough greater than the supply through *m*, to decrease that pressure in practically the same time and manner as is done by the high-speed reducing valve, until it is approximately 60 pounds. The application portion operates similarly to, but more quickly than, in the service application.

Emergency Lap. The above conditions continue until the brake cylinder pressure equals the *application-chamber* pressure, when parts of the valve assume the position known as the *Emergency Lap* and shown in Fig. 305.

The release after an emergency is the same as that following service applications.

Fig. 306 shows the position the distributing valve parts will assume, if the application-chamber pressure is discharged by the independent brake valve during an automatic application. This results in the upper movable portion going to the release position, and relieving brake-cylinder pressure, without changing the conditions in either the *pressure-chamber* or chamber *p;* consequently, the equalizing portion does not move, until released by the automatic brake valve.

Double Heading. It will be noted that in all of the above descriptions of the distributing valve, no reference has been made to the double-heading pipe connection. This is only used when the engine does not control the train brakes, and it then becomes an exhaust opening for the distributing valve when the automatic brake valve is on lap, and cut off from the brake pipe by the double cut-out cock. This will be better understood from the description of the pipe connections as already explained. The operation of the distributing valve is similar to that described during automatic brake applications with the

with the Distributing Valve and all Triple Valves on the cars in the train.

Brake-Cylinder Pipe: Connects the Distributing Valve with the Driver, Tender and Truck-Brake Cylinders.

Application-Chamber Pipe: Connects the Application Chamber of the Distributing Valve to the Automatic Brake Valve through the Independent Brake Valve.

Double-Heading Pipe: Connects the Application Chamber exhaust port of the Distributing Valve to the Automatic Brake Valve through the Double Cut-Out Cock.

ARRANGEMENT OF APPARATUS.

A piping diagram of the ET equipment is shown in Fig. 295.

Air compressed by the pump passes as usual to the main reservoirs and the reservoir pipe. The main-reservoir cut-out cock is to cut off the supply of air when removing any of the apparatus except the governor. The end toward the main reservoir is tapped for a connection to the maximum pressure head of the Pump Governor. When closed it discharges the air from the pipe between it and the automatic brake valve.

Beyond the main-reservoir cut-out cock, the reservoir pipe has four branches, one of which runs to the automatic brake valve, one to the feed valve, one to the reducing valve, and one to the distributing valve. As a result, the automatic brake valve receives air from the main reservoir in two ways, one direct and the other through the Feed Valve.

The Feed-Valve Pipe from the feed valve to the auto-

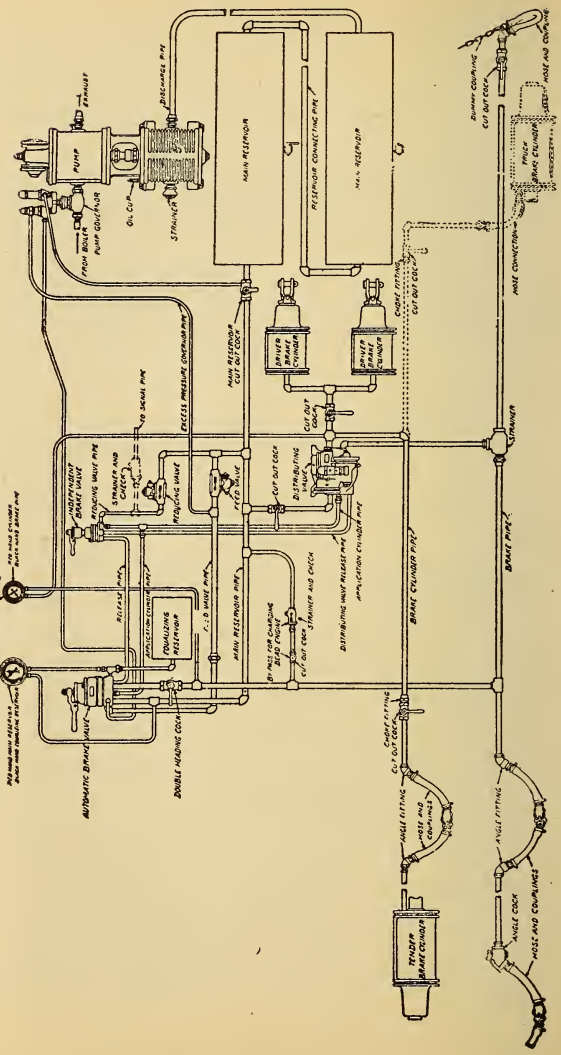


FIG. 295. PIPING DIAGRAM OF THE ET EQUIPMENT

matic brake valve has a branch to the top of the excess-pressure head of the duplex pump governor.

The third branch of the reservoir pipe connects with the reducing valve. Air at the pressure for which this valve is set (45 pounds) is thus supplied to the independent brake valve through the reducing-valve pipe. When the signal system is installed, it is connected to the reducing valve pipe, in which case the reducing valve takes the place of the signal reducing valve usually employed to supply the train air-signal system. In the branch pipe supplying the signal are placed a combined strainer and check-valve, and a special choke fitting. The former prevents any dirt from reaching the check valve and choke plug. The check valve prevents air from flowing back from the signal pipe when the independent brake is applied. The choke plug prevents the reducing valve from raising the signal-pipe pressure so quickly as to destroy the operation of the signal.

The distributing valve has five pipe connections, made through the double-chamber reservoir, three on the left and two on the right. Of the three on the left, the upper is the supply from the main reservoir; the intermediate is the double-heading pipe, leading through the double cut-out cock, when turned to cut out the brake valve from the brake pipe, to the automatic brake valve; and the lower is the application-chamber pipe, leading through the independent-brake valve, when the handle is in running position, to the automatic brake valve. Of the two on the right, the lower is the brake-pipe-branch connection, and the upper is the brake-cylinder pipe branching to all brake cylinders on the engine and tender. In this pipe are placed cocks for cutting out the brake cylinders when necessary, and in the engine truck and

tender brake cylinder cut-out cocks are placed special choke fittings to prevent serious loss of main-reservoir air, and the release of the other locomotive brakes during a stop, in case of burst brake cylinder hose connection. The cylinder gauge is connected with the brake cylinder pipe.

The automatic-brake-valve pipe connections, other than already mentioned, are the brake-pipe branch through the double cut-out cock, the main-reservoir, the equalizing reservoir, the duplex gauge, and the lower connection to the excess-pressure head of the pump governor.

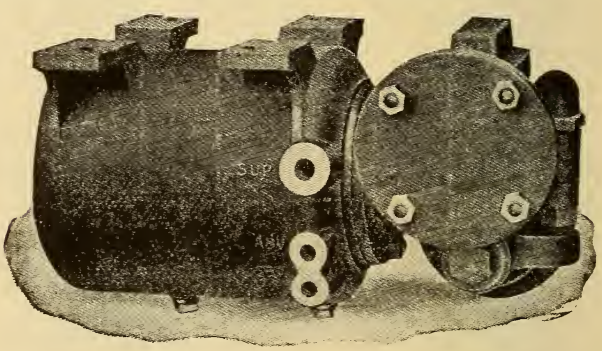


FIG. 296. DISTRIBUTING VALVE AND DOUBLE-CHAMBER RESERVOIR

CONNECTIONS:

SUP—Main-Reservoir Pipe; ABV—Double-Heading Pipe; SBV—Application-Chamber Pipe

THE DISTRIBUTING VALVE.

This valve is the important feature of the ET equipment. Fig. 296 is a photographic view of the left side of the valve and its double-chamber reservoir. The three pipe connections, as previously referred to, are plainly

shown. Fig. 297 is a similar view of the right side, showing the pipe connections there and the two chambers of

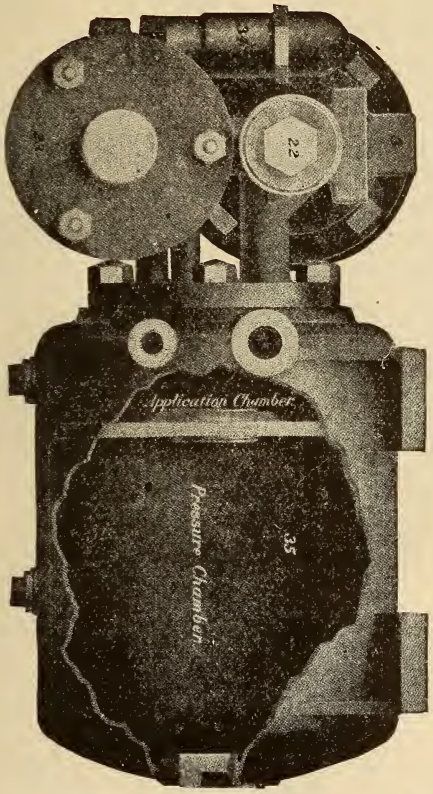


FIG. 297. DISTRIBUTING VALVE AND DOUBLE-CHAMBER RESERVOIR

PIPE CONNECTIONS:
Upper—Brake-Cylinder Pipe; Lower—Brake Pipe

the reservoir; also the safety valve 34, which is an essential part of the distributing valve. To simplify the tracing of the ports and connections, the various positions of this

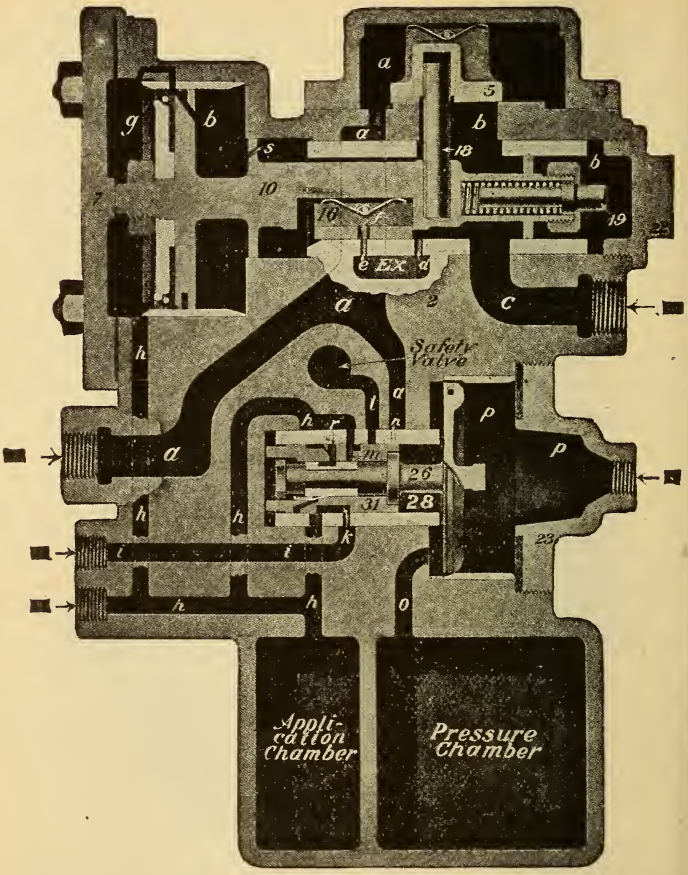


FIG. 298. THE DISTRIBUTING VALVE, DIAGRAMMATIC CONNECTIONS:

MR—Main-Reservoir Pipe; DH—Double-Heading Pipe; AC—Application-Chamber Pipe; BC—Brake Cylinder Pipe; BP—Brake Pipe

valve are illustrated in ten diagrammatic drawings; that is, the valve is distorted to show the parts differently than actually constructed, with the object of explaining the operation clearly instead of showing exactly how they are designed. The chambers of the reservoir are for convenience indicated at the bottom as a portion of the valve itself. In Fig. 308, equalizing piston 26, graduating valve 28, and equalizing slide valve 31, are shown as actually constructed. But as there are ports in the valves which cannot thus be clearly indicated, the diagrammatic illustrations show each slide valve in two parts, one below and the other above the piston stem, with similar division of parts in the bush.

Fig. 298 shows the operative parts in the same position as in Fig. 299 and is used merely for the sake of greater clearness. Referring to these figures it will be seen that main-reservoir pressure is always present in the chamber surrounding application valve 5 by its connection through passage *a, a,* to the main-reservoir pipe. Chambers *b* to the right of application piston 10 are always in free communication with the brake cylinder through passage *c* and brake-cylinder pipe. Chamber *g* at the left of application piston 10 is a portion of the application chamber, being always connected with it by passage *h,* and is also connected to the brake valves through the application-chamber pipe.

Independent Application. When the handle of the Independent Brake Valve is moved to the application position, air from the main reservoir, limited by the reducing valve to a maximum of 45 pounds, is allowed to flow to the application chamber, forcing application piston 10 to the right as shown in Fig. 300. We will assume that 45 pounds is so admitted and maintained. This

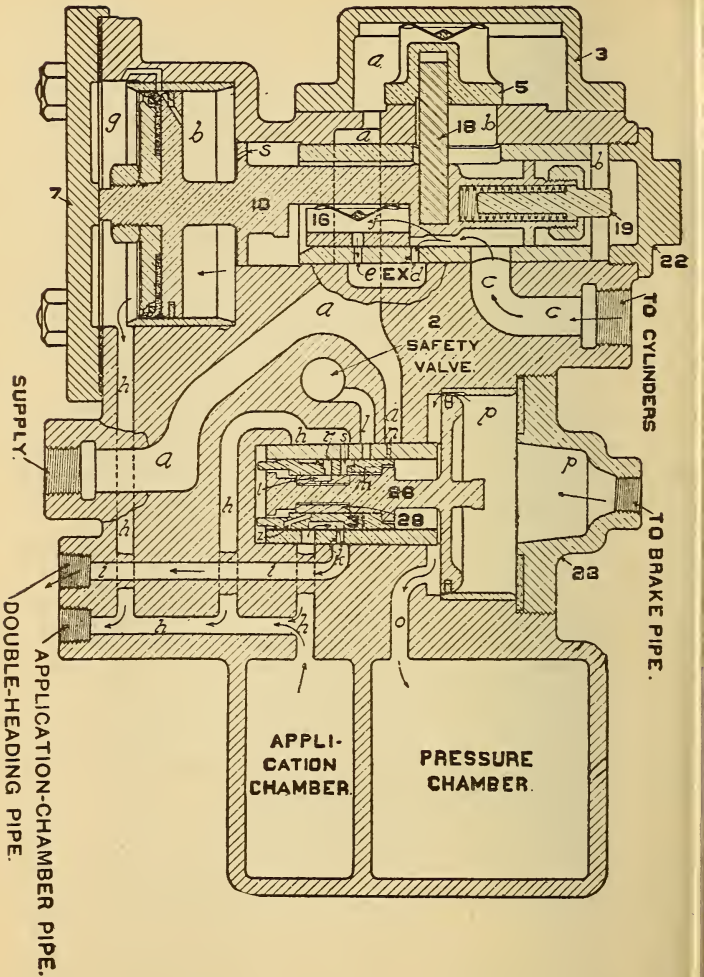


FIG. 299. RELEASE, AUTOMATIC OR INDEPENDENT

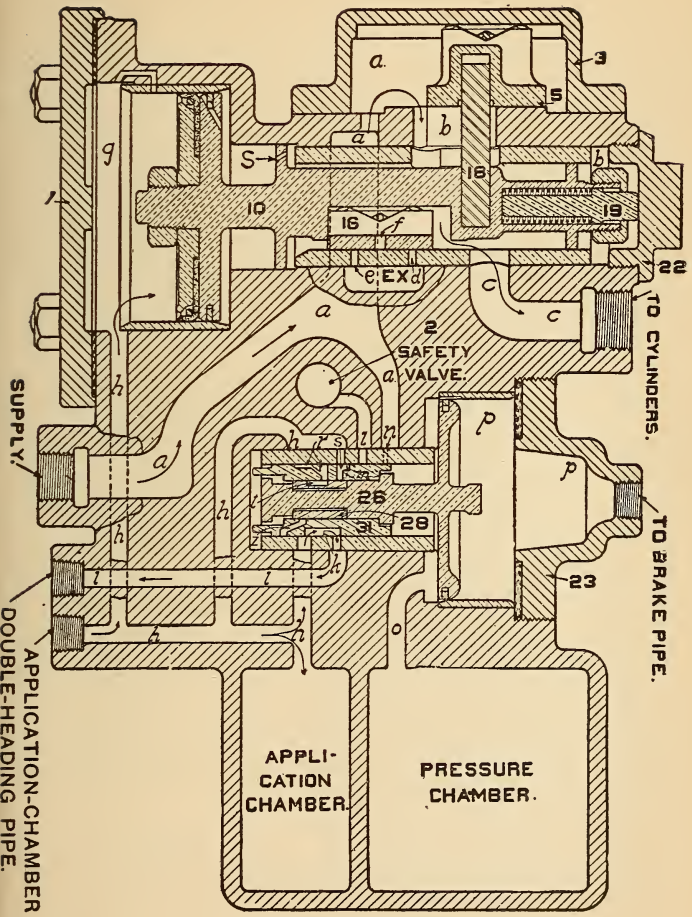


FIG. 300. INDEPENDENT APPLICATION

movement of application piston 10 causes exhaust valve 16 to close exhaust ports *e* and *d*, and the graduating stem 19 to compress its spring; also open application valve 5 by its connection with the piston stem by pin 18. Main reservoir air then flows through port *b* and passage *c* to the brake cylinders until their pressure and that in chamber *b* equals the application-chamber pressure, in this case 45 pounds. The graduating spring then forces the application piston 10 to the left until application valve 5 closes port *b*, but without moving exhaust valve 16. This position shown in Fig. 301 is known as INDEPENDENT LAP.

From the above description it will be seen that application piston 10 has application chamber pressure on one side and brake-cylinder pressure on the other. When either pressure varies, the piston will move toward the lower. Consequently if that in chamber *b* is reduced, by brake-cylinder leakage, the pressure maintained in the application chamber will force piston 10 to the right, opening application valve 5 and again admitting main reservoir air to the brake cylinders until the pressures on both sides of piston 10 are again equal, when the graduating spring will force the piston back to lap position. In this way the brake-cylinder pressure is always maintained to that in the application chamber. This is called the pressure maintaining feature.

INDEPENDENT RELEASE. When the handle of the independent brake is moved to release position, a direct opening is made through the rotary valve from the application chamber to the atmosphere. This permits the pressure in the application chamber to escape; therefore, as this pressure is being exhausted, brake-cylinder pressure in chamber *b* moves application piston 10 to the left,

the one shown in Fig. 292. It is obvious to state that these lever safety valves are also for use to keep the brake cylinder pressure within a certain prescribed limit, as, if they were not used, an application of the straight air brake, followed by one of the automatic, would greatly increase the brake cylinder pressure over the prescribed limit.

The quick release valve shown in Fig. 294, as before stated, is for use with schedule B2-S switch engine equipment. This valve is to hasten the release after an application of the automatic or straight air brakes. Referring to Fig. 294, connection A leads to the double check valve as shown in the piping diagram of this equipment. Connection B leads to the driver brake cylinders and connection X to the exhaust.

QUESTIONS.

904. What is the latest addition to the New York Duplex Air Brake System?

905. How many of these, and what are they?

906. Name the different systems covered by these three equipments?

907. In what leading features do the B2 equipments differ from older New York systems previously described?

908. What other advantage is gained by its use?

909. What advantage is gained by the use of the accelerator valve?

910. What other advantage is there in connection with its use?

911. For what conditions of service is the plain B2 designed.

912. For what class of service is the B2S equipment adapted?

913. For what class of service is the B2HP equipment designed only?

914. How many pressures may be carried in the brake pipe, or in the main reservoir, with the B2H.P.?

915. How are these pressures regulated?

916. How are the regulating portions operated?

917. For what kind of service is the B2H.S. equipment adapted?

918. How are the pressures regulated with this latter equipment?

919. How are the automatic brakes applied to locomotive and train?

920. How are they released?

921. How are the train brakes released, and the locomotive brakes held?

922. How are both released?

923. How are the locomotive brakes released?

924. How are the locomotive brakes (straight air) applied?

925. How are the brakes applied in an emergency?

926. In case a hose bursts, the train parts, or a conductor's valve opens thereby applying the brakes, what should be done?

927. After an application of the train brakes, how may the locomotive brakes be graduated off, or entirely released if desired?

928. How may the pressure in the locomotive brake cylinders be observed at all times?

929. When two, or more locomotives are in a train, what should be done with the air brake equipment on those locomotives from which the brakes are not operated?

930. In case it becomes necessary to cut out the straight air brake, what must be done?

931. How may the automatic brake be cut out?

932. How may the cut out cock be located so that the auxiliary reservoirs will remain charged while the brake is cut out?

933. What advantage would this be in descending long grades?

934. What are the functions of cut out cocks Nos. 3 and 6?

935. What is the function of main reservoir cut out cock No. 4?

936. What is the straight air controller designed for?

937. When should cut out cocks Nos. 5-6 and 7 be used?

938. Mention some of the principal points of difference between the B2 brake valve, and the B, and B1 valves?

939. What is the purpose of full automatic release, and straight air application position?

940. What functions are performed by the valve, in running, and straight air release position?

941. When should Lap position be used?

942. What are the functions of the graduating positions?

943. When is emergency position to be used?

944. What are some of the advantages gained by using the duplex pressure controller, and double pressure system?

945. What is the Accelerator valve designed to accomplish?

946. Is it automatic in operation?

947. What is the purpose of the straight air reducing valve?

948. When is the high speed controller, with lever safety valve operative?

ET LOCOMOTIVE BRAKE EQUIPMENT.

The new locomotive equipment illustrated and described in this article is designated by the symbol ET. It differs materially from the present combined automatic and straight air brake in that it consists of considerably less apparatus. In operation it possesses all the advantages of the latter type of brake equipment and several other important ones which are necessary in modern locomotive brake service to produce satisfactory results.

The design of the principal valves comprising the ET equipment is such that it may be applied to any locomotive regardless of the service in which it is employed without change or modification in any of its parts; and the locomotive so equipped may be used in any kind of service, such as high speed passenger, double-pressure control, all ordinary passenger and freight, and in all kinds of switching service, without change or special adjustment of the brake apparatus. All principal valves are so designed that they may be removed for repairs and replacement without disturbing the pipe joints.

In operation its important advantages are: The locomotive brakes may be controlled with or independently of the train brakes and this without regard to the position of the locomotive in the train, whether coupled to another, as in double heading, or used as a helper and assigned to any position in the train.

They may be applied with any desired pressure between the minimum and the maximum attainable, and

this pressure will be automatically maintained in the locomotive brake cylinders regardless of leakage and variation in piston travel, undesirable though these defects are, until released by the brake valve.

They can be perfectly graduated on or off either in the automatic or in the independent application; hence, in all kinds of service the train may be handled without shock or danger of parting, and in passenger service especially smooth, accurate stops can be made with greater ease than was heretofore possible.

MANIPULATION.

The instructions for manipulating the ET equipment are practically the same as those given for the combined automatic and straight air brake; therefore, no radical departure from present methods of brake manipulation is required to get the desired results.

The necessary instructions are briefly as follows:

When not in use, carry the handles of both brake valves in running position.

To apply the locomotive and train brakes, move the handle of the automatic brake valve to the service position, making the required brake-pipe reduction, then back to lap position, which is the one for holding brakes applied.

To release the train brakes, move the handle to the release position and hold it there until all train brakes are released; then, move it to holding position, graduating off the locomotive brakes by short, successive movements between running and holding positions, aiming to have the locomotive brakes entirely released as the train stops.

To apply the brakes in an emergency, move the handle of the automatic brake valve quickly to emergency position and leave it there until the train stops, or the danger is passed.

To make a smooth and accurate two-application passenger stop, make the first application sufficiently heavy to bring the speed of the train down to about 15 miles per hour at a convenient distance from the stopping point, then release train brakes by moving the handle to release position, then the locomotive brakes by moving it to running position for two or three seconds before re-applying. A little experience with the ET equipment will enable the engineer to make smooth and accurate stops with much greater ease than was heretofore possible.

When using the independent brake only, the handle of the automatic brake valve should be carried in running position. The independent application may be released by moving the independent-brake-valve handle to running position. Release position is for use when the automatic brake valve handle is not in running position.

While handling long trains of cars, in road or switching service, the independent brake should be operated with care and judgment, to prevent damage to the cars and lading, caused by running the slack in or out too hard. In cases of emergency arising while the independent brake is applied, apply the automatic brake instantly. The safety valve will restrict the brake cylinder pressure to the proper maximum. The brakes on the locomotive and on the train should be alternated in heavy grade service, to prevent overheating of driving-wheel tires and to assist the pressure retaining valves in holding the train while the auxiliary reservoirs are being recharged.

After all brakes are applied automatically, to gradu-

ate off or entirely release the locomotive brakes only, use release position of the independent brake valve.

The cylinder gauge will show at all times the pressure in the locomotive brake cylinders, and this gauge should be observed in all brake manipulation.

Release Position of the *Independent Brake Valve* will release the locomotive brakes under any and all conditions.

The train brakes should invariably be released before detaching the locomotive, holding with hand brakes where necessary. This is especially important on a grade as there is otherwise no assurance that the car, cars, or train so detached will not start when the air brakes leak off, as they may in a short time where there is considerable leakage.

The automatic brakes should never be used to hold a standing locomotive, or a train even where the locomotive is not detached, for longer than ten minutes, and not for such time if the grade is very steep or the condition of the brakes is not good. The safest method is to hold with hand brakes only, and keep the auxiliary reservoirs fully charged so as to guard against a start from brakes leaking off, and to be ready to obtain any part of full braking power immediately on starting.

The independent brake is a very important safety feature in this connection, as it will hold a locomotive with a leaky throttle, or quite a heavy train on a fairly steep grade if, as the automatic brakes are released, the slack is prevented from running in or out, depending on the tendency of the grade, and giving the locomotive a start. Illustrating the best method by a descending train, apply the independent brake heavily as the stop is being completed, thus bunching the train solidly; then, when stopped, place and *leave* the handle of the independent

brake valve in application position, release the automatic brakes and keep them charged. Should the train start through inability of the independent brakes to hold it, the automatic brakes will have been sufficiently recharged to make an immediate stop, and in which case enough hand brakes should be applied to render the necessary aid to the independent brakes.

Many runaways and some serious wrecks have resulted through failure to comply with the foregoing instructions.

When leaving the engine while doing work about it, or when it is standing at a coal chute or water plug, always leave the independent brake valve handle in application position.

In case the automatic brakes are applied by a bursted hose, a break-in-two or the use of a conductor's valve, place the handle of automatic brake valve in lap position.

Where there are two or more locomotives in a train, the double cut-out cock in the brake pipe under the automatic brake valve should be turned to close the brake pipe, and the automatic-brake-valve handle should be placed on lap on each except the one from which the brakes are being handled.

Before leaving the roundhouse, the engineer should try the brakes with both brake valves, and see that no serious leaks exist. The pipes between the distributing valve and the brake valves should be absolutely tight.

PARTS OF THE EQUIPMENT.

1. THE AIR PUMP to compress the air.
2. THE MAIN RESERVOIRS, in which to store the air and collect water and dirt.

3. A Duplex Pump Governor to control the pump when the pressures are attained for which it is regulated.

4. A Distributing Valve, and small double-chamber reservoir to which it is attached, placed on the locomotive to perform the functions of triple valves, auxiliary reservoirs, double check valve, high-speed reducing valves, etc.

5. Two Brake Valves, the Automatic to operate locomotive and train brakes, and the Independent to operate locomotive brakes only.

6. A Feed Valve to regulate the brake-pipe pressure.

7. A Reducing Valve to reduce the pressure for the independent brake valve, and for the air signal system when used.

8. Two Air Gauges; one, a Duplex to indicate brake-pipe and main-reservoir pressures; the other, a Single Pointer to indicate locomotive brake-cylinder pressure.

9. Driver, Tender, and Truck-Brake Cylinders, Cut-Out Cocks, Air Strainers, Hose Couplings, Fittings, etc., incidental to the piping, for purposes readily understood.

The piping hereafter referred to is named as follows:

Reservoir Pipe: Connects the main reservoir to the Automatic Brake Valve, Distributing Valve, Feed Valve, and Reducing Valve.

Feed-Valve Pipe: Connects the Feed Valve to the Automatic Brake Valve.

Reducing-Valve Pipe: Connects the Reducing Valve to the Independent Brake Valve, and to the Signal System, when used.

Brake Pipe: Connects the Automatic Brake Valve

ACCELERATOR VALVE.

This valve is designed to assist the Brake Valve in discharging brake pipe pressure when making service stops on long trains to bring about a more uniform application of the brakes, and to apply them more promptly than heretofore.

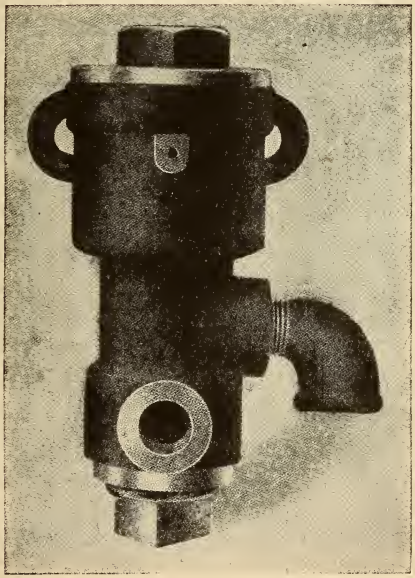


Fig. 287. Accelerator Valve.

The Valve is perfectly automatic in its operation, being governed entirely by the volume of air in the brake pipe, operating only when the train is of such a length

as to warrant the use of same. The operation is similar to that of the graduating mechanism in the Brake Valve, opening about four seconds after the Brake Valve handle has been moved to a graduating notch, and closing in about the same length of time after the graduating valve has closed.

Fig. 287 is an outside view of the Valve showing connection to brake pipe and exhaust which is through the street ell. A sectional view is shown in Fig. 288. The Valve is bolted to the end of the divided reservoir (Fig.

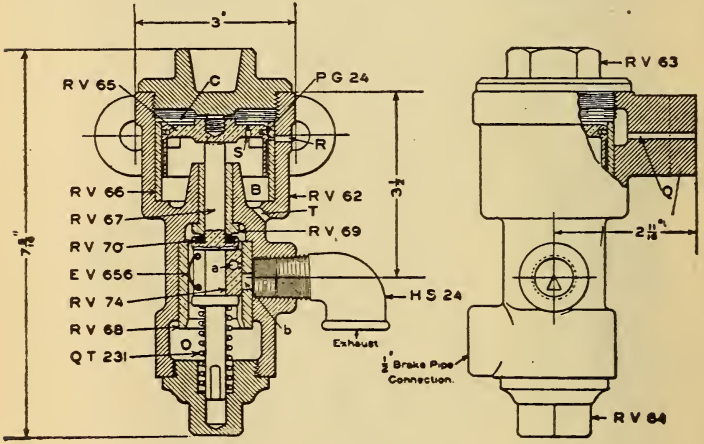


Fig. 288

279), and receives pressure from same through passage Q which connects to the space C above the piston RV 65. The brake pipe connection leads to the slide valve chamber O.

Chamber B is open to the atmosphere through port T, and in the operation of the Valve, will carry off the discharge of pressure through port S, and any leakage by the piston RV 65 or valve stem RV 67.

The slide valve RV 74, when at rest, laps the port b and exhaust, and is held in this position by the spring QT 231 through the medium of valve stem RV 67, which seats in the manner shown. Port b is triangular, the larger portion being at the bottom, and in operation brake pipe pressure is gradually cut off as the slide valve closes. Port a in the slide valve is oblong being just long enough to uncover the triangular port b, when the slide valve is wide open. To give the slide valve a slow closure port R is provided in the valve body, and port S through the piston RV 65 as shown. When the valve is in operation and brake pipe pressure is being discharged to the atmosphere through ports a and b, ports R and S are open to discharge the pressure above the piston and divided reservoir. As soon as the pressure in the divided reservoir has reduced sufficiently for the spring QT 231 to operate, it will move the valve slowly upward until the port R is cut off, which will then reduce the discharge from the reservoir about one-half, giving the slide valve the slow closure desired.

The valve operates when there are eight or more cars in a train, and requires from fifteen to seventeen pounds pressure in the divided reservoir to operate it. Any pressure passing into this reservoir, as with a shorter train than eight cars, will be discharged to the atmosphere through ports S and T, the slide valve remaining closed.

The proper names of parts of the accelerator valve are as follows: PG 24, Piston ring; RV 62, Body; RV 63, Upper cap; RV 64, Lower cap; RV 65, Piston; RV 67, Valve stem; RV 70, Leather seat; RV 74, Slide valve; QT 231, Spring; EV 656, Slide valve spring; HS 24, ½" Street ell.

STRAIGHT AIR REDUCING VALVE.

The purpose of this valve is to limit the pressure in the driver, and truck brake cylinders, to 40 pounds when using the straight air brake.

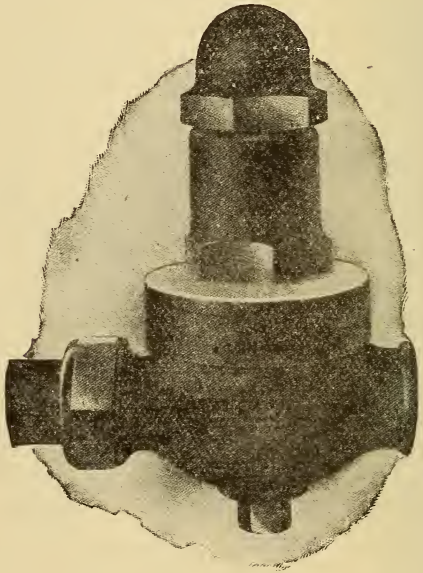


Fig. 289. Straight Air Reducing Valve.

Fig. 289 is a photographic view of the reducing valve and Fig. 290 a section showing the valves, passages, etc. Connection from the brake valve is made to the union fitting A and by means of the passage C pressure is free to pass to the feed valve SA 26. Connection B leads to

double check valve and brake cylinders. During the time the tension of the spring against the diaphragm is stronger than the force exerted against it by the brake cylinder pressure, valve SA 26 will be held open, whereupon pressure from the main reservoir will be free to pass to the brake cylinders. As soon as the pressure

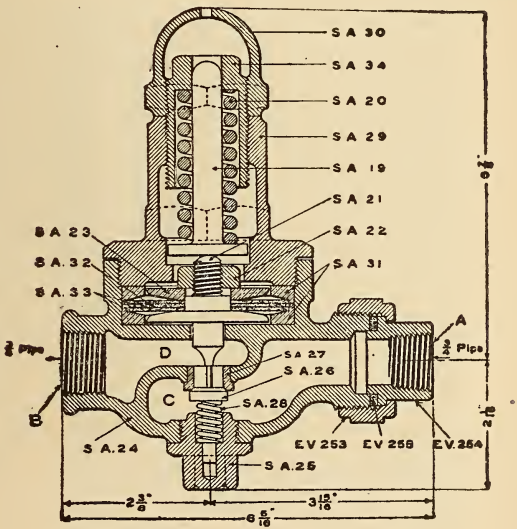


Fig. 290.

against the diaphragm is strong enough to overcome the resistance of the spring, the diaphragm will be moved upward, allowing the feed valve SA 26 to be closed by the spring SA 28, shutting off communication from the supply to the brake cylinders.

The names of the parts of this valve are as follows: SA 19, Regulating stem; SA 20, Regulating spring; SA

21, Diaphragm stem; SA 22, Nut; SA 23, Diaphragm Washer; SA 24, Body; SA 25, Feed valve cap nut; SA 26, Feed Valve; SA 28, Feed valve spring; SA 29, Spring box; SA 30, Check nut; SA 31, Diaphragm ring; SA 32, Diaphragm; SA 33, Diaphragm Shield; SA 34, Regulating nut; EV 253, ¾" Union nut; EV 254, ¾" Union swivel; EV 255, ¾" Union gasket.

HIGH SPEED CONTROLLER WITH LEVER SAFETY VALVE.

This valve is operative when the locomotive equipment is set for high speed service.

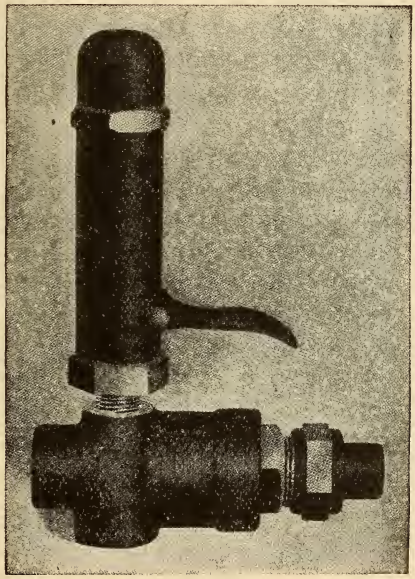


Fig. 291. High Speed Controller.

Fig. 291 is an outside view showing the general arrangement. Fig. 292 is a section showing the operative parts.

The Safety Valve is for use at all times to graduate off brake cylinder pressure after an application of the

train brakes when same is desired and to regulate the pressure in the brake cylinders during high speed operations. It is set at 53 pounds, and should so be adjusted in service.

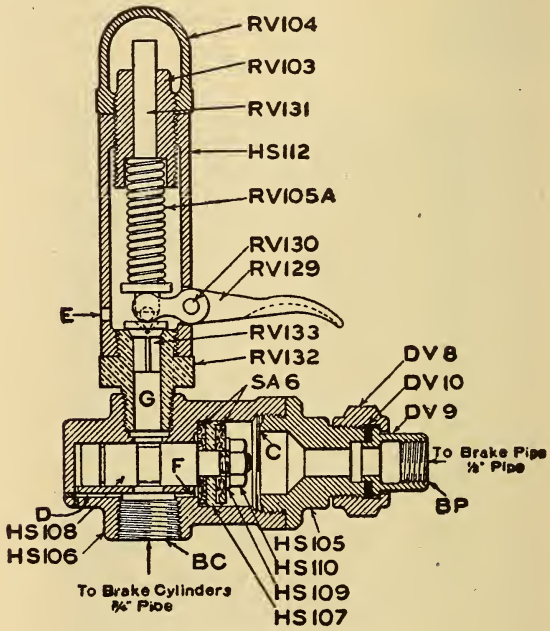


Fig. 292.

The High Speed Valve to which the Safety Valve is fastened connects with the brake cylinder pipe at BC and with brake pipe at BP.

The valve HS 108 with piston HS 107 operates when the brake pipe pressure is less than the pressure in brake cylinders. During all ordinary service applications the valve HS 108 will remain in position shown. In an emergency application when brake pipe pressure is

greatly reduced, the brake cylinder pressure will move the piston HS 107, and valve its full traverse to the seat C. This movement will restrict passage G leading to the safety valve, and atmosphere by the circular groove in the valve HS 108 being moved forward, closing a portion of the passage. This will give a gradual blow down from the brake cylinders through passage G until shut off by the Safety Valve. The valve will remain in this position until the brakes are released.

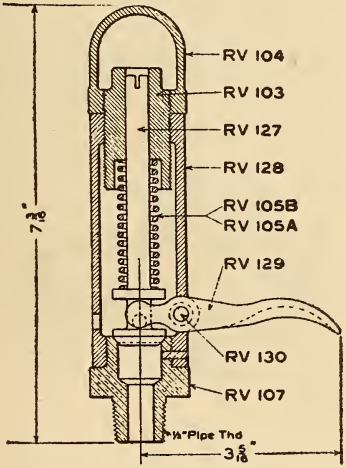


Fig. 293.

Ports F and D allow the brake cylinder pressure around the piston HS 107, and back of the valve HS 108, so that the piston is free to operate at a slight difference of pressure.

Fig. 293 is a sectional view of the lever safety valve, furnished with schedules B2, B2-S and B2-HP.

Fig. 294 shows the quick release valve which is used

with the B2-S equipment, for switch engine service, to quickly release the pressure from the driver brake cylinders.

The lever safety valves shown in Figs. 292 and 293 are for use at all times to graduate off brake cylinder pressure, after an application of train brakes, when the same is desired. These valves are set at fifty-three pounds, and should be so adjusted in service.

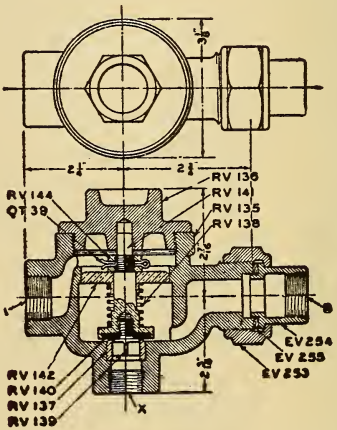


Fig. 294.

The two lever safety valves, although similar in appearance, are different in operation. In Fig. 292 the valve RV 133 is of a pop-safety valve design, and when forced open will remain so until the pressure beneath it has fallen to a trifle less than the force exerted against it by the spring RV 105 A. The safety valve shown in Fig. 293 is an ordinary blow-down pop valve, and while it will operate and reduce brake cylinder pressure to the desired amount, is not as free an operating valve as

Port X in the supply portion of the controller connects the under side of piston PG 4 with atmosphere, so that it will be free to operate and to discharge any leakage by the ring PG 24 or valve PG 95.

The regulating portions are provided with brackets so that they can be attached to the cab in some convenient place where they will be handy for adjustment. The adjustment of these regulating heads is accomplished by means of nut PG 35 which regulates the tension of spring PG 10.

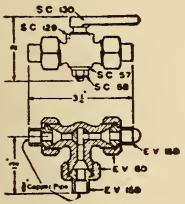


Fig. 284.

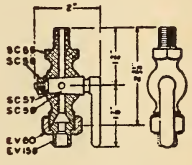


Fig. 285.

Each regulating head has a vent port C, and to avoid any unnecessary waste of air, one of these heads should be plugged with screw PG 33. The cut-out cock shown in Fig. 285 is used with the B2S equipment, between the regulating and supply portions. When this cock is closed the supply portion of the controller is cut off.

The hand wheel PG 45 can be used in descending grades if desired, to increase the brake pipe pressure to that of the main reservoir. By screwing the wheel up, it will lift the valve PG 95 off its seat and thus allow the two pressures to become equal. The Controller will then be inoperative, and main reservoir pressure will be free to pass to the brake pipe until the Controller is again restored to its operative condition.

The names of parts of the regulating portion are: PG 3A Spring Casing; PG 10 Regulating Spring; PG 12A and B Diaphragm button; PG 13 Diaphragm; PG 14 Air valve seat; PG 32 Diaphragm body; PG 33 Vent plug; PG 34 Cap; PG 35 Regulating nut; PG 36 Air union swivel (⅜″ copper pipe); PG 37 Air union nut; PG 98 Duplex bracket; EV 60 Small union nut; EV 128 Small union stud; EV 158 small union swivel (⅜″ copper pipe). The parts of the three-way cock are: SC 57 Washer; SC 58 Nut; SC 129 Body; SC 130 Plug; EV 60 Small union nut; EV 158 Union Swivel (⅜″ copper pipe).

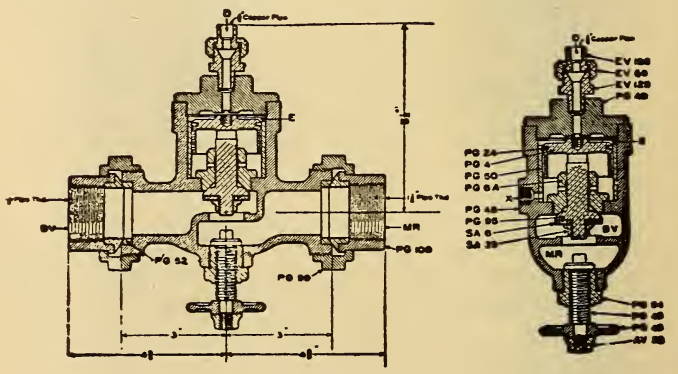


Fig. 286.

The parts of the supply portion are: PG 4 Piston; PG 6A Valve guide; PG 24 Piston ring; PG 45 Hand wheel; PG 46 Lifting Stem; PG 48 Body; PG 49 Cap; PG 94 Guide; PG 95 Valve; PG 99 1¼″ union nut; PG 100 1¼″ union swivel; EV 60 Small union nut; EV 128 Small union stud; EV 158 Union swivel (⅜″ copper pipe); SA 6 Leather seat; SA 39 Valve stem nut; AV 28 Hand wheel nut.